layer and no more bleeding. The teeth received a periapical radiograph prior to extraction and were extracted at 28 or 90 days. The teeth were evaluated radiographically and histologically. These researchers concluded that on the basis of symptomatic, clinical, radiographic, and histological findings, the CO$_2$ laser compares favorably to formocresol pulpotomies.

A study was performed comparing a conventional formocresol–ZOE pulpotomy with a diode laser-MTA pulpotomy. In this study, the teeth were studied clinically and radiographically for a period of up to 15.7 months. The researchers concluded that the laser-MTA pulpotomy showed slightly reduced radiographic success rates compared to the formocresol–ZOE pulpotomy, but the results were not statistically significant. They recommended that a larger sample with a longer follow-up was needed to consider the laser-MTA as an alternative to the formocresol–ZOE pulpotomy.\cite{127}

In a study by Huth et al.,\cite{128} four pulpotomy techniques were compared: calcium hydroxide, Er:YAG, dilute formocresol, and ferric sulfate on a sample of 200 primary molars treated and followed for up to 24 months. The teeth were anesthetized and isolated with a rubber dam, and the caries was excavated and the roof of each pulp chamber removed with a diamond bur. The coronal pulp was removed with a slow-speed round bur and a spoon excavator. Hemostasis was obtained by placing wet cotton pellets with slight pressure in the chamber for 5 minutes. Formocresol-medicated cotton pellets were applied to the pulp for 5 minutes in the control group. In the laser group, the teeth were treated with an Er:YAG laser set at 2 Hz and 180 mJ per pulses without water cooling. The mean number of laser pulses per tooth was 31.5 ± 5.9. In the calcium hydroxide group, the teeth were dressed with aqueous calcium hydroxide and covered with calcium hydroxide cement. In the last group, the teeth were treated with cotton pellets wetted with ferric sulfate for 15 seconds. All of the teeth received an IRM base, followed by a glass ionomer cement and a stainless steel crown, or a composite resin. The teeth were followed clinically and radiographically for up to 24 months. After 24 months, the total (combined clinical and radiographic success rates) and clinical success rate percentages (in parenthesis) were as follows: formocresol 85 (96%), laser 78 (93%), calcium hydroxide 53 (87%), and ferric sulfate 86 (100%). The authors concluded that calcium hydroxide was significantly less effective than formocresol. They also pointed out that an increased sample size would be necessary before it could be definitively said that this laser technique or ferric sulfate was equal to, or better, than formocresol.

A study by Liu,\cite{129} which was conducted similarly to his previously published case report, using an Nd:YAG laser with follow-up for up to 64 months demonstrated a 97% clinical success rate and a 94.1% radiographic success rate for the laser group that was compared to the 85.5% clinical success rate and a 78.3% radiographic success rate for the formocresol control group.

Odabas et al.\cite{130} performed a clinical, radiographic, and histological study of Nd:YAG laser pulpotomies compared to formocresol pulpotomies on 42 primary teeth studied for a period of up to 12 months. This study was conducted nearly identically to the previous studies. The laser group had a clinical success rate of 85.71%, and a radiographic success rate of 71.42%, at 9 and 12 months. The formocresol group had a clinical success rate of 90.47% and a radiographic success rate of 90.47% at 9 and 12 months. These researchers conclude that the Nd:YAG laser may be considered as an alternative to formocresol for pulpotomies for primary teeth.

As lasers become more commonplace in dentistry, dentists who own a laser now have a body of research literature to justify the use of the laser to perform pulpotomies for children in their practices.

### Ferric Sulfate

The use of ferric sulfate as a primary tooth pulpotomy medicament begins to appear in the literature in the late 1980s when Landau and Johnson\cite{131} published an abstract describing the use of ferric sulfate as a pulp medicament in monkey’s teeth. The sample size was small and followed for only 60 days. They noted secondary dentin formation and partial dentin bridging. They also described ferric sulfate as a “promising medicament for teeth indicated for pulpotomies.” Subsequently, Fei et al.\cite{132} presented the first clinical study of ferric sulfate as a pulpotomy medicament for primary teeth. In this study, 29 primary molars received ferric sulfate pulpotomies and 27 received 1:5 Buckley’s formocresol pulpotomies. Both groups received a ZOE base and were followed over 12 months. Criteria for clinical success included no symptoms of pain, no tenderness to percussion, no swelling or fistula, and no pathological mobility. Criteria for radiographic success included normal periodontal ligament space, no pathological internal or external resorption, and no furcal or apical radiolucency. Results of the study showed that after 1 year, 28 of 29 of the ferric sulfate-treated teeth were considered successful while only 21 of 27 of the formocresol-treated teeth were...
considered successful. Combined overall success rates were 96.6% for the ferric sulfate group and 77.8% for the formocresol group. They raised some interesting points in their discussion. The use of ZOE as a base for formocresol pulpotomies is standard for this procedure. A ZOE base is also paired with ferric sulfate in order to standardize the two pulpotomy treatments. The authors suggested that ZOE is appropriate for formocresol because the pulp tissue is somewhat fixed from formocresol and would not react with the slightly irritating eugenol. Because ferric sulfate is not a tissue fixative, and probably leaves the tissue in a more vital state, using ZOE as a base introduces an irritant that may contribute to failure. They suggested that it would be advisable to continue to study ferric sulfate as a primary tooth pulp medicament for longer periods of time and with more inert base materials.

Additional animal studies on rat and baboon teeth have been performed to assess histologically the pulpal healing response after pulpotomy with ferric sulfate and dilute formocresol. In her study using rats, Cotes had four test groups pairing ferric sulfate and dilute formocresol each with ZOE and polycarboxylate cements. She demonstrated that in the coronal third of the teeth tested, there was necrosis for all groups tested. In the middle third, there was a lesser degree of inflammation for the dilute formocresol–ZOE and ferric sulfate–polycarboxylate groups. In the apical third, the dilute formocresol–ZOE group showed the least inflammation. In addition, reparative dentin formation was noted in the apical third of the pulp in the ferric sulfate–ZOE group while it was not found in the other groups. Conclusions from this study include the following: dilute formocresol–ZOE produced the least inflammation, the use of polycarboxylate cement as a substitute for ZOE did not improve the pulpal response, and significant differences were not found regarding the pulpal inflammation between ZOE and polycarboxylate cements.

Fuks et al. studied ferric sulfate and dilute formocresol pulpotomies in baboon teeth. Both medications produced similar degrees of pulpal inflammation and dentin bridging. Sixty percent of the teeth had normal pulps and the remaining 40% had severe inflammation. They recommended more clinical study of ferric sulfate. A number of clinical studies comparing ferric sulfate and formocresol pulpotomies have been performed. In 1997, Fuks et al. performed dilute formocresol and ferric sulfate pulpotomies and evaluated the teeth for up to 34 months. They concluded that dilute formocresol and 15.5% ferric sulfate have similar success rates. Smith et al. performed a retrospective study of clinical and radiographic data from the charts of patients who received ferric sulfate pulpotomies and ZOE base. They followed 242 teeth for 4 to 57 months (mean, 19 months). Their clinical success rate was 99% and the radiographic success rate was 74% to 80%. The longer the teeth were followed, the more failures were noted radiographically. The most common pathological radiographic observations were calcific metamorphosis and internal resorption (Figure 11). Ninety percent of the teeth survived after 3 years. They concluded that ferric sulfate has a success rate similar to dilute formocresol. In addition, if the radiographic changes are separated into dental and osseous categories, and the

Figure 11 A, Radiograph showing internal resorption in a primary molar after ferric sulfate pulpotomy. B, Resorption resulted in perforation (arrow). C, Perforated area resulting from the resorptive process (arrow).
dental changes (internal resorption and calcific metamorphosis) are reclassified as acceptable variations of success, then the radiographic success rate would be 84% to 92%. The only radiographic changes that would be classified as failures were interradicular or periapical bone destruction and external resorption. These investigators also suggest that since the goal is to keep the pulpotomized tooth asymptomatic until exfoliation, some degree of dental changes is acceptable as long as it does not cause pain or any symptoms.

Additional clinical and retrospective studies and one evidence-based assessment conclude that ferric sulfate and dilute formocresol have similar clinical and radiographic rates of success. Vargas demonstrated that both ferric sulfate and formocresol pulpotomies can cause early exfoliation of the pulpotomized teeth with the subsequent need of space maintenance until the premolar erupts.

While most of the published studies on ferric sulfate compare it to formocresol pulpotomy, Casas et al. took a different path, comparing it instead to primary tooth root canal therapy (pulpectomy). Root canal therapy with a plain ZOE obturation and ferric sulfate pulpotomy were found to have similar success rates up to about 2 years, but past 2 years, the root canal treatment had better success. They suggested that complete obturation of the canal rather than the partial treatment of the pulp is the best treatment for pulpally involved primary teeth. They did concede that it will be difficult to get the pediatric dental community to change because of the relatively high success rates of pulpotomy, because this was the treatment they learned as a student or a resident, and because pulpotomy is a simple treatment and some children are not cooperative enough to sit for a pulpectomy treatment (Figure 12).

Mineral Trioxide Aggregate

MTA has only recently been recommended as a pulp capping agent in primary teeth. The first published clinical trials in primary teeth began in 2001 and in animal studies occurred in 2003 to 2004 in rat and dog teeth.

A study involving rat first molars demonstrated that after 2 weeks the treated teeth responded well to MTA and were attempting to form dentinal bridges. In the 4-week samples, dentin bridges were completely formed at the pulp–MTA interface and the pulps appeared normal. In the dog study, the researchers tested white and gray MTA as well as regular and white Portland cements as pulpotomy medicaments. Seventy-six teeth from mongrel dogs received pulpotomy treatments. The teeth were evaluated after 120 days and all four of the materials were found to have similar results. The pulps healed with dentin bridges that completely closed the pulpotomy access preparations and the pulps appeared normal. The researchers concluded that both MTA and Portland cement were good pulp capping agents, and they further suggested that Portland cement has the potential to be used as a less expensive material in endodontics. They did not address the fact that Portland cement is not approved for human use.

A number of human studies using MTA as a pulp capping material in primary teeth have demonstrated that MTA performs as well or better than formocresol. Teeth in these studies were followed for periods of 6 to 74 months. Pulp canal obliteration was a common finding in teeth treated with MTA. Various authors conclude that MTA is a reasonable replacement for formocresol because of its high success rates and it lacks the undesirable side effects of formocresol. Studies that tested both gray and white MTA concluded that the gray formulation produces better results than the white. While MTA has shown excellent results as a pulp capping agent for primary teeth pulpotomies, the one factor that seems to keep it from becoming the new gold standard replacement for formocresol is the cost of the material. Only time will tell if MTA will replace formocresol as the most commonly used pulp capping material for primary teeth.

Nonvital Pulp Therapy for Children

In children, complete root canal treatment on primary teeth is often referred to as a pulpectomy procedure. While the term pulpectomy only refers removal of the pulp, this term in pediatric dentistry has come to mean removal of the caries and the inflamed or necrotic
pulp, cleaning and shaping the root canals, and obtura-
tion of the tooth with a resorbable root filling material.
Pulpectomy is indicated when a tooth has irreversible
pulpitis or a necrotic pulp or when a tooth has been
treatment planned for a pulpotomy and excessive
hemorrhage (hyperemia) is encountered at the time
of treatment.1 Some pediatric dentists prefer pulpect-
omy procedure for primary anterior teeth even if the
tooth could be a candidate for only a pulpotomy
procedure or if the tooth has only reversible pulpitis
symptoms because they believe a complete obturation
of the canal is preferable to partial obturation whenever
possible. A number of articles recommend pulpectomy
as a substitute for all pulpotomies.151–153

Pulpectomy procedures for primary teeth must be done
with a consideration for the subjacent succedaneous tooth
(Figure 13). It begins with profound pulpal
anesthesia followed by placement of a rubber dam.

Figure 12 Pulpotomy technique. A, Primary molar with large carious lesion. B, Caries removed and pulp exposed. C, Pulp tissue removed from the chamber. D, Pulp space being treated with ferric sulfate. E, After treatment with ferric sulfate. F, ZOE base has been placed.
All caries are removed with a slow-speed round bur or a spoon excavator (Figure 14). From the point of the pulp exposure, an access preparation is made by connecting the pulp horns with the bur. This creates the outline of the access preparation. The roof of the chamber and the coronal pulp are removed. The access preparation is refined to make sure that access to all of the canals is possible. There should be slight flaring of the access to allow for ease of insertion of the files.

In clinical situations where a primary incisor has no caries but has been affected by dental trauma that caused a gray discoloration, the access can be performed from the facial. It is very similar to a lingual access, as it connects the pulp horns and makes a triangular-shaped preparation that is combined with a facial veneer preparation. Following pulpectomy, the tooth can be restored with a light composite resin in the pulp chamber to veneer the facial surface of the tooth to mask the discoloration.

To remove the radicular pulp in anterior teeth, a good technique is to insert two very small files (size 10 or 15) on either side of the pulp and twist the files removing the whole pulp in one motion. In posterior teeth, a barbed broach is used. The canals can be irrigated with sodium hypochlorite or sterile saline. It will be necessary to irrigate the canal several times throughout the procedure.

Files are measured 1 mm short of the apex by comparing them to the length of the tooth on a radiograph. This gives a preliminary working length. It is important to avoid extending instruments into the
apical area. The file is inserted into the canal and with tactile sense felt for an apical stop (Figure 15). An alternative method is to insert a medium or a large-sized file (medium for molars and larger files for anterior teeth) into the canal of the tooth and feel for an apical stop. This measurement is then compared to the radiograph. After the correct length is established, smaller files are set to this length. Studies have shown that electronic apex locators can accurately be used when treating primary teeth.154,155 Excessive cleaning and shaping of the canal should be avoided since that can damage the tooth and lead to extraction caused by perforation in the furcation or the lateral wall of a canal. The purpose of filing is to remove the pulp tissue and make room for the root canal filling material. After the canals are cleaned, they should be irrigated again and dried with appropriately sized sterile paper points.

There are a number of choices of root canal filling materials that can be used for primary teeth, and each of these materials has an appropriate obturation technique (Figure 16). Unreinforced zinc oxide and eugenol is a very common material and is easily placed into the canal with a rotary paste filler (Figure 17). It is very important that commercially prepared zinc oxide cements, with reinforcing fibers, not be used, as these reinforced cements are not well resorbed. The unreinforced ZOE is mixed into a thick paste. Large rotary spirals work well for maxillary anterior teeth, and small spirals are suited for molars and mandibular incisors. The rotary spiral is inserted into the canal while it is not turning and is used to search for the apical stop. The paste filler is then slightly removed so that it is short of the apical stop and the handpiece is revolved slowly. The dental assistant places the ZOE on the spatula next to the revolving paste filler that pulls the ZOE off the spatula and introduces the cement into the canal. The speed of the handpiece can be adjusted to cause the ZOE to completely fill the canal. When the dentist believes that the canal is completely filled, the paste filler is removed while still rotating. If the paste filler is removed after it has stopped, it will pull the ZOE from the canal.

A periapical radiograph is then exposed to determine the adequacy of the root canal filling. If the
canal is not completely filled, the paste filler is reintroduced into the canal to achieve a better obturation. Small amounts of ZOE overfill can be expected to be resorbed uneventfully although it is better to have an underfill than an overfill. The tooth is then restored and monitored until it exfoliates \(^\text{21,22,151,156}\) (Figures 18 and 19).

There have been many articles that quantify the success rate of pulpectomy and root canal treatments in primary teeth. In 1978, Jokinen et al.\(^\text{157}\) studied 1,304 pulpectomies and found that only 53% were successful. Success rates in the mandible and maxilla were nearly equal. This study is of historical interest, but it is difficult to use these results in judging today’s dental care because the technique was very different than the average pulpectomy that is performed today.

Flaitz et al.\(^\text{158}\) followed 87 pulpectomies in primary incisors that were obturated with ZOE, with a drop of formocresol in the cement mixture, for a period of 37.4 months. They found a success rate of 84%. In a follow-up study of 62 patients over a period of 12 to 74 months, these same researchers demonstrated a success rate of 82.3% for primary molar pulpectomies with a ZOE filling material.\(^\text{159}\) Yacobi\(^\text{153}\) et al. performed ZOE pulpectomies on both primary incisors and molars on 51 children over a period of 12 months and found a success rate of 76% for the anterior teeth and a success rate of 84% for the posteriors. Payne et al.\(^\text{160}\) studied primary 253 anterior and posterior primary teeth for up to 24 months. Their success rate for anterior teeth was...
82.8% and 90.3% for posterior teeth. Coll et al.\textsuperscript{161} followed 65 ZOE pulpectomies for a period of 90.8 months. The overall success rate was 77.7%. Two additional studies provide success rates of 76% and 78.5% for ZOE pulpectomies.\textsuperscript{162,163}

Rifkin\textsuperscript{164} used Kri Paste (a mixture of p-chlorophenol, camphor, menthol, and iodoform) to treat 45 primary teeth. The teeth were treated in either 1 or 2 appointments depending on the symptoms. After 1 year, 42 of the 45 teeth were asymptomatic. Garcia-Godoy\textsuperscript{165} treated 55 primary teeth with multiple appointment pulpectomies, obturated with Kri Paste, and followed for up to 2 years. There were no clinical or radiographic signs or symptoms in 95.6% of the teeth. Coll et al.\textsuperscript{166} compared 41 pulpectomies on primary teeth with pulp necrosis that were obturated with Kri Paste over a period of up to 6 years 10 months. The teeth had a success rate of over 80%. An additional study by Coll\textsuperscript{167} confirmed this success rate. Another study by Reyes and Reina\textsuperscript{168} with a similar technique documented a 100% success rate. Thomas et al.\textsuperscript{169} studied 36 primary teeth for 3 months after pulpectomies and obturated with iodoform paste. They found a success rate of 94.4%. Holan and Fuks\textsuperscript{170} compared ZOE- and Kri Paste-filled pulpectomies on primary molars evaluated for periods up to 48 months. They demonstrated a success rate of 84% for Kri Paste and 65% for ZOE. After a number of clinical studies using Kri Paste for pulpectomies, Wright et al.\textsuperscript{171} performed an in vitro antimicrobial and cytotoxic study of Kri Paste and ZOE. In this study, they found that ZOE had better antimicrobial activity and that both materials had similar cytotoxicity.

Hendry\textsuperscript{172} and his fellow researchers performed pulpectomies using calcium hydroxide and plain ZOE on mongrel dogs. They exposed the pulps of the dogs to produce inflamed pulps. The teeth were later instrumented and obturated with either calcium hydroxide or ZOE. Clinical, radiographic, and histological evaluations of both calcium hydroxide and ZOE found that the calcium hydroxide specimens were more successful in all areas. Another study by Mani et al.\textsuperscript{173} compared 60 ZOE and calcium hydroxide pulpectomies. Combined clinical and radiographic success rates were 83.3% for the ZOE group and 86.7% for the calcium hydroxide group. Ozalp et al.\textsuperscript{174} found a success rate of 80 to 90% for pulpectomies that were obturated with calcium hydroxide.

Vitapex (NeoDental International, Inc., Federal Way, WA) is a commercially prepared calcium hydroxide and iodoform mixture that is prepackaged in syringes specifically for pulpectomies. It has been tested by a number of researchers. A case report by Nurko et al.\textsuperscript{175} recommends it as an excellent material for pulpectomies in spite of some problems with resorption of the material. Three additional studies document the use of Vitapex with follow-up of up to 22 months; the success rates approached 100%.\textsuperscript{162,174,176}

One in vitro study by Tchaou et al.\textsuperscript{177} compared various dental materials used in pulpectomies for primary teeth for bacterial inhibition. They compared calcium hydroxide mixed with camphorated p-chlorophenol (Ca(OH)\textsubscript{2} + CPC), calcium hydroxide mixed with sterile water (Ca(OH)\textsubscript{2} + H\textsubscript{2}O), zinc oxide mixed with CPC (ZnO + CPC), zinc oxide mixed with eugenol (ZOE), ZOE mixed with formocresol (ZOE + FC), zinc oxide mixed with sterile water (ZnO + H\textsubscript{2}O), ZOE mixed with chlorhexidine dihydrochloride (ZOE + CHX), Kri paste, Vitapex paste, and Vaseline. They found that the materials could be divided into three groups. Category I with the strongest antibacterial effect included ZnO + CPC, Ca(OH)\textsubscript{2} + CPC, and ZOE + FC. Category II with a medium bacterial effect included ZOE + CHX, Kri, ZOE, and ZnO + H\textsubscript{2}O. Category III with no or minimal antibacterial effect included Vitapex, Ca(OH)\textsubscript{2} + H\textsubscript{2}O, and Vaseline.
There are many articles that describe aspects of the pulpectomy technique and the instruments involved in the procedure. Once a primary molar begins to resorb, from physiological resorption or from pathology, it can be difficult for the dentist to know if the canals of the tooth can be properly instrumented or even to obtain a correct working length. Rimondini and Baroni\textsuperscript{178} studied 80 primary molars in children 4 to 12 years old, 75 of which were extracted because of pulpal involvement. The teeth were measured and the apices and areas of resorption were located. They found that roots that were longer than 10 mm were related to a curved root shape with no external resorption. Roots with length between 4 to 7 mm were associated with advanced root resorption. Roots that were shorter than 4 mm were associated with resorption and perforation of the furcation. They identified 4 mm as the limit of the length of a root that can be treated successfully.

Barr et al.\textsuperscript{179} presented the use of rotary nickel–titanium files to prepare primary teeth for pulpectomy treatment. Advantages of this technique include ease of removal of tissue and debris, flexible design allowing access to canals, files prepare the canal in a funnel shape to ease obturation, and the files are available in 21 mm length. Disadvantages of the use of these files include cost of the equipment (handpiece), increased cost of the files, and the time required to learn the technique. An in vitro study was performed on three pulpectomy filling devices: Lentulo spiral (Dentsply International), NaviTip (Ultradent Products, Inc., South Jordan, UT), and Vitapex syringe (NeoDental International), and Coll\textsuperscript{166,167} have shown that ZOE cement was retained in the alveolus in 49.4% to 73.3% of the exfoliated teeth, and this material was still retained in 27.3% of the patients after 40.2 months. Short-filled pulpectomies were significantly less likely to overretain ZOE.\textsuperscript{161} One of the two studies evaluated over 6,000 charts in a pediatric dentistry private practice.\textsuperscript{183} Jerrell and Ronk\textsuperscript{184} presented a case study of the arrest of eruption of a permanent premolar after ZOE material was extruded from the primary molar pulpectomy into the developing tooth bud. Fortunately in the case of this particular patient, premolar extraction was a part of the patient’s orthodontic treatment plan, so the tooth was extracted. It is reassuring that studies have shown a low incidence of enamel hypoplasia in succedaneous teeth when the primary teeth have been treated with pulpectomy techniques.\textsuperscript{161,166}

Educational Curricula and Attitudes of Pediatric Dentists

A study by Avran\textsuperscript{185} in 1987 surveyed pediatric dentistry residencies in Canada and a number of dental schools worldwide. He found that in Canada among pediatric dental specialists, the preferred pulp medicament for 50% of the respondents was 1:5 formocresol and full-strength formocresol was preferred by 42.2%. In Canadian pediatric dental residency programs, full-strength formocresol was preferred by 40.8% of respondents and 1:5 formocresol was preferred by 36%. Seventy percent of respondents in Scandinavian dental schools preferred calcium hydroxide. This is not unexpected since much of the research on calcium hydroxide as a pulp medicament has been done there. When respondents were asked if they were considering a change to another medicament, many said they would consider glutaraldehyde.

A second study was published by Primosch\textsuperscript{186} in 1997 based on a survey of the pediatric dental
programs in the United States regarding curricula for pulp therapy in children. Calcium hydroxide was the preferred base for pulp capping. Most schools taught that after the first appointment of an indirect pulp cap, it would be necessary to reenter the tooth only if the patient experienced symptoms. A 1:5 dilution of formocresol was the most commonly (71.7%) recommended medicament for pulpotomy procedure, and it was left in the tooth for 5 minutes (94.3%). ZOE was the most commonly recommended base (92.4%). It is interesting to note that while some practitioners were considering changing from formocresol to glutaraldehyde in Avram’s study in the 1980s, no US dental school included glutaraldehyde in the curriculum in the 1997 study. Further, the Primosh’s study reported that 2 of 53 dental schools in 1997 were teaching ferric sulfate or 1:5 formocresol to their students. While interest in glutaraldehyde has decreased, interest and research on ferric sulfate has greatly increased.

In regard to pulpectomy procedure, 98% of US dental schools were teaching hand instrumentation of canals, with the majority of schools not recommending any enlargement of the canal. The most commonly recommended irrigants were sodium hypochlorite, sterile water or saline, and local anesthetic. Ninety percent of schools recommended zinc oxide and eugenol as the preferred filling for root canals. These two studies have now become outdated. So why include this information? These are only two journal articles that quantify what is being taught in dental schools. It is important to realize that formocresol has been advocated as a pulp medicament for a very long time, and it seems to be very entrenched in pediatric dental education. While it may have a number of problems, no substitute has

Figure 20  A, Large caries on primary incisors at the time of diagnosis. B, Approximately 3 years after endodontic treatment. C, Five and half years after treatment, the primary tooth is retained and deflecting permanent successor. D, The primary incisor has been extracted. Radiograph shows retained zinc oxide–eugenol (ZOE) material. The right primary incisor was subsequently extracted.
been overwhelmingly advocated to take its place. It is certain that there is much room for research on new pulp medicaments to replace formocresol.

Conclusion

Endodontic therapy, from pulp capping, pulpotomy or to pulpectomy, is an excellent procedure to prevent the premature loss of primary teeth. When the appropriate treatment is selected for each situation, success and preservation of the tooth can be anticipated. Vital pulp therapy is indicated when the pulp has the potential for healing, and nonvital pulp therapy is indicated when irreversible pulpitis or necrosis exists. Preserving primary teeth keeps young smiles beautiful and dental arches intact preventing space loss and malocclusion.

References


96. Hill SD, Berry CW, Seale NS, Kaga M. Comparison of antimicrobial and cytotoxic effects of glutaraldehyde and


Various methods of restoring pulpless teeth have been reported for more than 200 years. In 1747, Pierre Fauchard described the process by which roots of maxillary anterior teeth were used for the restoration of single teeth and the replacement of multiple teeth (Figure 1). Posts were fabricated of gold or silver and held in the root canal space with a heat-softened adhesive called “mastic.” The longevity of restorations made using this technique was attested to by Fauchard: “Teeth and artificial dentures, fastened with posts and gold wire, hold better than all others. They sometimes last fifteen to twenty years and even more without displacement. Common thread and silk, used ordinarily to attach all kinds of teeth or artificial pieces, do not last long.”

The replacement crowns were made from bone, ivory, animal teeth, and sound natural tooth crowns. Gradually the use of these natural substances declined, to be slowly replaced by porcelain. A pivot (what is today termed a post) was used to retain the artificial porcelain crown into a root canal and the crown-post combination was termed a “pivot crown.” Porcelain pivot crowns were described in the early 1800s by a well-known dentist of Paris, Dubois de Chemant. Pivoting (posting) of artificial crowns to natural roots became the most common method of replacing artificial teeth and was reported as the “best that can be employed” by Chapin Harris in The Dental Art in 1839.

Early pivot crowns in the United States used seasoned wood (white hickory) pivots. The pivot was adapted to the inside of an all-ceramic crown and also into the root canal space. Moisture would swell the wood and retain the pivot in place. Surprisingly, Prothero reported removing two central incisor crowns with wooden pivots that had been successfully used for 18 years. Subsequently, pivot crowns were fabricated using wood/metal combinations and then more durable all-metal pivots were used. Metal pivot retention was achieved by various means such as threads, pins, surface roughening, and split designs that provided mechanical spring retention.

Unfortunately, adequate cements were not available to these early practitioners, cements that would have enhanced post retention and decreased abrasion of the root caused by movement of metal posts within the canal. One of the best representations of a pivoted tooth appears in Dental Physiology and Surgery, written by Sir John Tomes in 1849 (Figure 2). Tomes’ post length and diameter conformed closely to today’s principles in fabricating posts.

Endodontic therapy, by these dental pioneers, embraced only minimal efforts to clean, shape, and obturate the canal. Frequent use of the wooden posts in empty canals led to repeated episodes of swelling and pain. Wooden posts, however, did allow the escape of the so-called “morbid humors.” A groove in the post or the root canal provided a pathway for continual suppuration from the periradicular tissues.

Although many of the restorative techniques used today had their inception in the 1800s and early 1900s, proper endodontic treatment was neglected until years later. Today, both endodontic and prosthodontic aspects of treatment have advanced significantly, new materials and techniques have been developed, and a substantial body of scientific knowledge is available upon which to base clinical treatment decisions.

The purpose of this chapter is to answer questions frequently encountered when dental treatment involves endodontically treated teeth and to describe the techniques commonly employed when restoring these
teeth. Whenever possible, the answers and discussion will be supported by scientific evidence. Conflicting results will be presented to provide a comprehensive understanding of the available evidence.

Should Crowns Be Placed on Endodontically Treated Teeth?

A retrospective study of 1,273 teeth endodontically treated 1 to 25 years previously compared the clinical success of anterior and posterior teeth. Endodontically treated teeth with restorations that encompassed the tooth (onlays, partial or complete coverage metal crowns, and metal ceramic crowns) were compared with endodontically treated teeth with no coronal coverage restorations. It was determined that coronal coverage crowns did not significantly improve the success of endodontically treated anterior teeth. This finding supports the use of a conservative restoration such as an etched resin restoration in the access opening of otherwise intact or minimally restored anterior teeth. Crowns are indicated only on endodontically treated anterior teeth when they are structurally weakened by the presence of large and/or multiple coronal restorations or they require significant form/color changes that cannot be effected by bleaching, resin bonding, or porcelain laminate veneers. Scurria et al. collected data from 30 insurance carriers in 45 states regarding the procedures 654 general dentists performed on endodontically treated teeth. The data indicated that 67% of endodontically treated anterior teeth were restored without a crown, supporting the concept that many anterior teeth are being satisfactorily restored without the use of a crown.

When endodontically treated posterior teeth (with and without coronal coverage restorations) were compared, a significant increase in the clinical success was noted when cuspal coverage crowns were placed on maxillary and mandibular molars and premolars. In a study of 116 failed and extracted endodontically treated teeth, Vire reported that teeth restored with crowns had greater longevity than uncrowned teeth. A strong association was found between crown placement and the survival of endodontically treated teeth. If long-term tooth survival is the primary goal, placing
a crown on an endodontically treated posterior tooth enhances survival (Figure 3). Therefore, restorations that encompass the cusps should be used on posterior teeth that have intercuspation with opposing teeth and thereby receive occlusal forces that push the cusps apart. The previously discussed insurance data\(^7\) indicated that 37 to 40% of posterior endodontically treated teeth were restored by practitioners without a crown, a method of treatment not supported by the long-term clinical prognosis of posterior endodontically treated teeth that do not have cusp-encompassing crowns. There are, however, certain posterior teeth (not as high as 40%) that do not have substantive occlusal intercuspation or have an occlusal form that precludes intercuspation of a nature that attempts to separate the cusps (such as mandibular first premolars with small, poorly developed lingual cusps). When teeth are intact or minimally restored (small MO or DO restorations), they would be reasonable candidates for restoration of only the access opening without the use of a coronal coverage crown.\(^10\)

In contrast to the above recommendations, a 3-year clinical study by Mannocci et al.\(^11\) evaluated the clinical success rate of endodontically treated premolars restored with a post and direct composite resin restorations with and without complete crown coverage. They found that both had a similar success rate. Nagasiri et al.,\(^12\) in a retrospective cohort study, indicated that when endodontically treated molars are completely intact except for a conservative access opening, they could be restored successfully by using composite resin restorations.

Multiple clinical studies of fixed partial dentures, many with long spans and cantilevers, have determined that endodontically treated abutments failed more often than vital teeth due to tooth fracture,\(^13–17\) supporting the greater fragility of endodontically treated teeth and the need to design restorations that reduce the potential for both crown and root fractures when extensive fixed prosthodontic treatment is required.

Gutmann\(^18\) reviewed the literature and presented an overview of several articles that identify what happens when teeth are endodontically treated. These articles provide background information important to an understanding of why coronal coverage crowns help prevent fractures of posterior teeth. Endodontically treated dog teeth have been found to have 9% less moisture than vital teeth.\(^19\) In addition, it was found that dehydration increases stiffness and decreases the flexibility in teeth. However, dehydration by itself does not account for the physical property changes in dentin.\(^20\) Also, with aging, greater amounts of peritubular dentin are formed, which decreases the amount of organic materials that may contain moisture. It has been shown that endodontic procedures reduce tooth stiffness by 5%, attributed primarily to the access opening.\(^21\)

Tidmarsh\(^22\) described the structure of an intact tooth that permits deformation when loaded occlusally...
and elastic recovery after removal of the load. The direct relationship between tooth structure removed during tooth preparation and tooth deformation under load has been described. Dentin from endodontically treated teeth has been shown to exhibit significantly lower shear strength and toughness when compared with vital dentin. Rivera et al. stated that the effort required to fracture dentin may be less when teeth are endodontically treated because of more immature (potentially weaker) collagen intermolecular cross-links. In a recent study, it was found that collagen fibrils degraded over time in teeth with zinc phosphate-cemented posts. Acid demineralization can also occur from bacteria and acid etching.

CONCLUSIONS
Restorations that encompass the cusps of endodontically treated posterior teeth have been found to increase the clinical longevity of these teeth. Therefore, crowns should be placed on endodontically treated posterior teeth that have occlusal intercuspation with opposing teeth of the nature that places expansive forces on the cusps. Since crowns do not enhance the clinical success of anterior endodontically treated teeth, their use on relatively sound teeth should be limited to situations where esthetic and functional requirements cannot be adequately achieved by other more conservative restorations (Figure 4).

With Pulpless Teeth, Do Posts Improve Long-Term Clinical Prognosis or Enhance Strength?
Historically, the use of posts was based on the concept that a post reinforces the tooth.

LABORATORY DATA
Virtually all laboratory studies have shown that placement of a post and core either fails to increase the fracture resistance of endodontically treated extracted teeth or decreases the fracture resistance of the tooth when a force is applied via a mechanical testing machine. Lovdahl and Nicholls found that endodontically treated maxillary central incisors were stronger when the natural crown was intact except for the access opening than when they were restored with cast posts and cores or pin-retained silver amalgams. Lu found that posts placed in intact endodontically treated central incisors did not lead to an increase in the force required to fracture the tooth or in the position and angulation of the fracture line. Pontius found that maxillary incisors, without posts, resisted higher failure loads than the other groups with posts and crowns. Gluskin found that mandibular incisors with intact natural crowns exhibited greater resistance to transverse loads compared with teeth with posts and cores. McDonald found no difference in the impact fracture resistance of mandibular incisors with or without posts. Eshelman and Sayegh reported similar results when posts were placed in extracted dog lateral incisors. Guzy and Nicholls determined that there was no significant reinforcement achieved by cementing a post into an endodontically treated tooth that was intact except for the access opening. Leary et al. measured the root deflection of endodontically treated teeth before and after posts of various lengths were cemented into prepared root canals. They found no significant differences in strength between the teeth with or without a post. Trope et al. determined that preparing a post space weakened endodontically treated teeth compared with ones in which only an access opening was made, but no post space.

A potential situation where a post and core could strengthen a tooth was identified by Hunter et al. using photoelastic stress analysis. They determined that removal of internal tooth structure during endodontic therapy is accompanied by a proportional increase in stress. They also determined that minimal root canal enlargement for a post does not substantially weaken a tooth but when excessive root
canal enlargement has occurred, a post strengthens the tooth. Therefore, if the walls of a root canal are thin due to the removal of internal root caries or overinstrumentation during post preparation, then a post may potentially strengthen the tooth.

Two-dimensional finite element analysis was used in one study\textsuperscript{37} to determine the effect of posts on dentin stress in pulpless teeth. When loaded vertically along the long axis, a post reduced maximal dentin stress by as much as 20%. However, only a small (3 to 8%) decrease in dentin stress was found when a tooth with a post was subjected to masticatory and traumatic loadings at 45° to the incisal edge. The authors proposed that the reinforcement effect of posts is doubtful for anterior teeth because they are subjected to angular forces.

**CLINICAL DATA**

Sorensen and Martinoff\textsuperscript{38} evaluated endodontically treated teeth with and without posts and cores. Some of the teeth were restored with single crowns while others served as fixed partial denture abutments or removable partial denture abutments. Posts and cores significantly decreased the clinical success rate of teeth with single crowns, improved the clinical success of removable partial denture abutment teeth, and had little influence on the clinical success of fixed partial denture abutments. Eckerbom et al.\textsuperscript{39} examined the radiographs of 200 consecutive patients and reexamined the patients radiographically 5 to 7 years later to determine the prevalence of apical periodontitis. Of the 636 endodontically treated teeth evaluated, 378 had posts and 258 did not have posts. At both examinations, apical periodontitis was significantly more common in teeth with posts than in endodontically treated teeth without posts. Morfis\textsuperscript{40} evaluated the incidence of vertical root fracture in 460 endodontically treated teeth, 266 of which had posts. There were 17 teeth with root fracture after a time period of at least 3 years. Nine of the 17 fractured teeth had posts and 8 root fractures occurred in teeth without posts. Morfis\textsuperscript{40} concluded that the endodontic technique can cause vertical root fracture. In an analysis of data from multiple clinical studies, Goodacre\textsuperscript{41} found that 3% of teeth with posts fractured. None of these clinical data provide definitive support for the concept that posts and cores strengthen endodontically treated teeth or improve their long-term prognosis.

**THE PURPOSE OF POSTS**

Since clinical and laboratory data indicate that teeth are not strengthened by posts, their purpose is for retention of a core that will provide appropriate support for the definitive crown or prosthesis. Unfortunately, this primary purpose has not been completely recognized. Hussey\textsuperscript{42} noted that 24% of general dental practitioners felt that a post strengthens teeth. A 1994 survey (with responses from 1066 practitioners and educators) revealed some interesting facts. Ten percent of the dentist respondents felt that every endodontically treated tooth should receive a post. It was determined that 62% of dentists over age 50 believed a post reinforces the tooth whereas only 41% of the dentists under age 41 believed in that concept. Thirty-nine percent of part-time faculty, 41% of full-time faculty, and 56% of nonfaculty practitioners felt that posts reinforce teeth.\textsuperscript{43}

**CONCLUSIONS**

Both laboratory and clinical data fail to provide definitive support for the concept that posts strengthen endodontically treated teeth. Therefore, the purpose of a post is to provide retention for a core.

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**What Is the Clinical Failure Rate of Posts and Cores?**

Several studies provide clinical data regarding the number of posts and cores that failed over certain time periods\textsuperscript{44–55} (Table 1). When this number is divided by the total number of posts and cores placed, a failure rate is calculated to determine the clinical success rate of posts and cores.

<table>
<thead>
<tr>
<th>Lead Author</th>
<th>Study Length</th>
<th>Percentage of Clinical Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turner (1982)*</td>
<td>5 years</td>
<td>9 (6 of 66)</td>
</tr>
<tr>
<td>Sorensen (1984)</td>
<td>1–25 years</td>
<td>9 (36 of 420)</td>
</tr>
<tr>
<td>Bergman (1989)*</td>
<td>6 years</td>
<td>9 (9 of 96)</td>
</tr>
<tr>
<td>Weine (1991)*</td>
<td>10 years or more</td>
<td>7 (9 of 138)</td>
</tr>
<tr>
<td>Hatzikyriakos (1992)*</td>
<td>3 years</td>
<td>11 (17 of 154)</td>
</tr>
<tr>
<td>Mentink (1993)*</td>
<td>1–10 years (mean 4.8)</td>
<td>8 (39 of 516)</td>
</tr>
<tr>
<td>Wallerstedt (1984)*</td>
<td>4–10 years (mean 7.8)</td>
<td>14 (8 of 56)</td>
</tr>
<tr>
<td>Torbjörner (1995)</td>
<td>4–5 years</td>
<td>9 (72 of 788)</td>
</tr>
<tr>
<td>Balkenhol (2006)</td>
<td>1–9 years (mean 2.1)</td>
<td>7 (50 of 802)</td>
</tr>
<tr>
<td>Valderhaug (1997)</td>
<td>1–25 years (mean 2.1)</td>
<td>10 (40 of 397)</td>
</tr>
<tr>
<td>Mean values\textsuperscript{*}</td>
<td>8 years</td>
<td>9 (292 of 3433)</td>
</tr>
</tbody>
</table>

*Studies used to calculate mean study length.
\textsuperscript{*}Calculation made by averaging numerical data from all studies.
percentage is determined. A 9% overall average for failure was calculated by averaging the failure percentages from 10 studies (an average study length of 6 years). In these studies, the failure percentage ranged from 7% to 14%.

A review of more specific details from the 10 studies provides insight into the length of each study and the number of posts and cores evaluated. The findings of a 5-year retrospective study of 66 posts and cores indicate there were 6 failures and a 9% failure rate. An additional study found that 17 of 154 posts failed after 3 years for an 11% failure rate. A failure rate of 9% was found in three studies. Two studies reported a 7% post and core failure rate after 9 years or more. An 8% failure rate (39 of 516 posts and cores) was published when 516 posts and cores placed by senior dental students were retrospectively evaluated, whereas another study recorded a 14% failure rate (8 failures in 56 posts and cores) from posts and cores placed by dental students. A study of 397 posts followed for 25 years reported a 10% post and core failure rate after 25 years (40 of 397 posts failed).

Kaplan-Meier survival statistics (percentage of survival over certain time periods) were presented or could be calculated from the data in nine studies (Table 2). The survival rates ranged from a high of 99% after 10 years or more of follow-up to a 78% survival rate after a mean time of 5.2 years. The failure percentage per year has also been calculated and ranged from 1.56% per year to 4.3% per year.

**CONCLUSIONS**

Posts and cores had an average clinical failure rate of 9% (7 to 14% range) when the data from 10 studies were combined (average study length of 8 years).

**What Are the Most Common Types of Post and Core Failures?**

Eight studies indicate that post loosening is the most common cause of post and core failure (44,45,47,48,50,55–57, Figure 5). Turner reported on 100 failures of post-retained crowns and indicated that post loosening was the most common type of failure. Of the 100 failures, 59 were caused by post loosening. The next most common occurrences were 42 apical abscesses followed by 19 carious lesions. There were 10 root fractures and 6 post fractures. In another paper by Turner, he reported the findings of a 5-year retrospective study of 52 post-retained crowns. Six posts had come loose, which was the most common failure. Lewis and Smith reported data regarding 67 post and core failures after 4 years. Forty-seven of the failures resulted from post loosening, 8 from root fractures, 7 from caries, and 4 from bent or fractured posts. Bergman et al. found 8 failures in 96 posts after 5 years. Six posts had loosened and 2 roots had fractured. Hatzikyriakos et al. reported on 154 posts and cores after 3 years. Five posts had come loose, five crowns had come loose, four roots fractured, and caries caused three failures. Mentink identified 30 post loosenings and 9 tooth fractures when evaluating 516 posts and cores over a 1- to 10-year time period (4.8 years mean study length). Torbjörner et al. reported on the frequency of three technical failures (loss of retention, root fracture, and post fracture). They did not report biological failures. Loss of retention was the most frequent post failure, accounting for 45 of the 72 post and core failures. Root loosening was the second most common cause (20 failures). The third most common cause was caries (12 failures). The remaining failures were caused by root fractures (7 failures) and post fractures (4 failures).
fracture (Figure 6) was the second most common failure cause followed by post fracture. Balkenhol et al. reported on 802 posts and cores over a 10-year period. Thirty-nine posts had loosened, eight had longitudinal root fracture, and six had transverse root fracture.

In two studies, factors other than loss of retention were listed as the most common cause of failure. Sorensen and Martinoff evaluated 420 posts and cores and recorded 36 failures. Of the 36 failures, 8 were related to restorable tooth fractures, 12 to non-restorable tooth fractures, 13 to loss of retention, and 3 were caused by root perforations. Weine et al. found 9 failures in 138 cast posts and cores after 10 years or more. Three failures were caused by restorative procedures, two by endodontic treatment, two by periodontal problems, and two by root fractures. No posts failed due to loss of retention.

Four studies have provided data on the incidence of tooth fracture but no information regarding post loosening. Linde reported that 3 of 42 teeth fractured, Ross found no fractures with 86 posts, Morfis found that 10 of 266 teeth fractured, and Wallerstedt identified 2 fractures with 56 posts.

Loss of retention and tooth fracture (in that order of occurrence) are the 2 most common causes of failure when these studies are collectively analyzed by averaging the numerical data from all the studies. Five percent of the posts placed (144 of 2,980 posts)
experienced loss of retention (Table 3). Two percent of the posts placed (82 of 3,827 posts) failed via tooth fracture (Table 4).

**CONCLUSIONS**

Loss of retention and tooth fracture are the two most common causes of post and core failure.

**Which Post Design Produces the Greatest Retention?**

**LABORATORY DATA**

There have been many laboratory studies comparing the retention of various post designs. Threaded posts provide the greatest retention, followed by cemented,
parallel-sided posts. Tapered cemented posts are the least retentive. Cemented, parallel-sided posts with serrations are more retentive than cemented, smooth-sided parallel posts. These laboratory data are discussed below.

CLINICAL DATA
There is clinical support for these laboratory studies. Torbjo¨rner et al. reported significantly greater loss of retention with tapered posts (7%) compared with parallel posts (4%). Sorensen and Martinoff determined that 4% of tapered posts failed by loss of retention whereas 1% of parallel posts failed in that manner. Turner indicated that tapered posts loosened clinically more frequently than parallel-sided posts. Lewis and Smith also found a higher loss of retention with smooth-walled tapered posts than parallel posts. Bergman et al. and Mentink et al. evaluated only tapered posts, and both studies reported that 6% of tapered posts failed via loss of retention, values higher than those recorded by Torbjörner et al. and Sorensen and Martinoff for parallel posts.

Contrasting results were reported by Weine et al. They found no clinical failures from loss of retention with cast tapered posts. Hatzikyriakos et al. studied tapered threads, parallel cemented posts, and tapered cemented posts. The only posts that loosened from the root were parallel cemented posts.

CONCLUSIONS
Tapered posts are the least retentive and threaded posts the most retentive in laboratory studies. Most of the clinical data support the laboratory findings.

Is There a Relationship Between Post Form and the Potential for Root Fracture?

LABORATORY DATA
Using photoelastic stress analysis, Henry determined that threaded posts produced undesirable levels of stress. Another study used strain gauges attached to the root and compared four parallel-sided threaded posts with one parallel-sided non-threaded post. Two of the threaded posts produced the highest strains, whereas two other threaded posts caused strains comparable to the nonthreaded post. Standlee et al., using photoelastic methods, indicated that tapered, threaded posts were the worst stress producers. When three types of threaded posts were compared in extracted teeth, Deutsch et al. found that tapered threaded posts increased root fracture by 20 times that of the parallel threaded posts (Figure 7).

Laboratory testing of split threaded posts has provided varying results, but more research groups have concluded that they do not reduce the stress associated with threaded posts. Thorsteinsson et al. determined that split threaded posts did not reduce stress concentration during loading. In another study, split threaded posts were found to produce installation stresses comparable to other threaded posts. Greater stress concentrations than those of some other threaded posts were reported under simulated functional loading. Rolf et al. found that a split threaded post produced comparable stress to one type of threaded post and less stress than a third threaded post design. Ross et al. determined that a split threaded post produced less root strain than two other threaded posts and comparable strain to a third threaded post and a nonthreaded post. Another research group concluded that the split threaded design reduced the stresses caused during cementation compared with a rigid threaded post design. Multiple photoelastic stress studies have concluded that posts designed for cementation produced less stress than threaded posts.

When parallel-sided cemented posts were compared with tapered cemented posts, photoelastic stress testing results generally favored parallel-sided posts. Using this methodology, Henry found that parallel-
sided posts distribute stress more evenly to the root. Finite element analysis studies produced similar results. Two additional photoelastic studies concluded that parallel posts concentrate stress apically and tapered posts concentrate stress at the post–cementoenamel junction. Also using photoelastic testing, Assif et al. found that tapered posts showed equal stress distribution between the cementoenamel junction and the apex compared with parallel posts that concentrated the stress apically.

When fracture patterns in extracted teeth were used to compare parallel and tapered posts, the evidence favoring parallel posts was less favorable. Sorensen and Engelman determined that tapered posts caused more extensive fractures than parallel-sided posts did, but the load required to create fracture was significantly higher with tapered posts. Lu, also using extracted teeth, found no difference in the fracture location between prefabricated parallel posts and cast posts and cores. Assif et al. tested the resistance of extracted teeth to fracture when the teeth were restored with either parallel or tapered posts and complete crowns. No significant differences were noted, and post design did not influence fracture resistance.

In analyzing the stress distribution of posts, it was noted that tapered posts generate the least cementation stress and should be considered for teeth that have thin root walls, are nearly perforated, or have perforation repairs.

**CLINICAL DATA**

There are several clinical studies that provide data related to the incidence of root fracture associated with different post forms. Some of these studies provide a comparison of multiple post forms, whereas other studies evaluated only one type of post. Combining all the root fracture data for each post form from both types of studies reveals some interesting trends (Table 5). Five studies present data regarding root fractures and threaded posts, four regarding fractures associated with parallel-sided cemented posts and nine related to tapered cemented posts. If the total number of threaded posts evaluated in the five studies is divided into the total number of fractures found with threaded posts, a percent value can be determined that represents the average incidence of tooth fracture associated with threaded posts in the five studies. The same data can be calculated for parallel cemented and tapered cemented posts, permitting a comparison of the root fracture incidences associated with these three post forms.

Combining the five studies that reported data relative to threaded posts produced a mean fracture rate of 7% (11 fractures from 169 posts). The four clinical studies that contain fracture data from parallel-sided cemented posts produced a mean fracture incidence of 1% (9 fractures from 867 posts). From the seven studies reporting root fracture with tapered posts, there is a mean fracture rate of 2% (66 root fractures from 2,752 posts). This combined study data support the previously cited photoelastic laboratory stress tests, indicating that the greatest incidence of root fractures occurred with threaded posts and that the lowest incidence of root fracture was associated with parallel cemented posts. In a meta-analysis of selected clinical studies, Creugers et al. calculated a 91% tooth survival rate for cemented cast posts and cores and an 81% survival rate for threaded posts with resin cores.

While the combined data from all the studies for each type of post revealed certain trends, analysis of individual studies (where multiple post forms were compared in the same study) produced less conclusive results. One study of threaded posts and cemented posts determined that teeth with threaded posts were lost more frequently than teeth with cast posts. In three other clinical comparisons of threaded and cemented posts, no tooth fracture differences were noted. In addition to the comparisons of threaded and cemented posts, four clinical studies provide data comparing the tooth fracture incidences associated with parallel-sided and tapered posts. In comparing parallel and tapered posts by reviewing dental charting records, a higher failure rate was reported with tapered posts than with parallel posts.
in two studies, and the failures were judged to be more severe with tapered posts.\textsuperscript{46,48} Two other clinical studies determined that there were no differences between tapered and parallel-sided posts.\textsuperscript{48,75} Hatzikyriakos et al.\textsuperscript{45} found no significant differences between 47 parallel cemented posts and 44 tapered cemented posts after three years of service. Ross\textsuperscript{75} evaluated 86 teeth with posts and cores that had been restored at least five years previously. No fracture differences were found between 38 tapered cemented posts and 39 parallel cemented posts.

Unfortunately, the total number of clinical studies that compared multiple post forms in the same study is limited. Also, several factors may have affected the findings of available studies. Two of the papers that contained a comparison of multiple post forms covered sufficiently long time periods (10 to 25 years) that the tapered cemented posts may have been in place much longer than the parallel-sided cemented posts (due to the later introduction of parallel posts into the dental market).\textsuperscript{46,48} The mean time since the placement of each post form was not identified in these studies. Also, both of these studies were based on reviews of patient records (rather than clinical examinations) and depended on the accuracy of dental charts in determining if and when posts failed as well as the cause of the failure. Another factor that affected the results of many of the referenced clinical studies was the length of the posts. For instance, in Sorensen and Martinoff’s study,\textsuperscript{46} 44% of the tapered cemented posts had a length that was half (or less than half) the incisocervical or occlusocervical dimension of the crown whereas only 4% of the parallel cemented posts were that short. Since short posts have been associated with higher root stresses in laboratory studies, the difference in post length may have affected their findings where tooth fractures occurred with 18 of 245 tapered posts compared with no fractures with 170 parallel posts.

**CONCLUSIONS**

When evaluating the relationship between post form and root fracture, laboratory tests generally indicate that all types of threaded posts produce the greatest potential for root fracture. When comparing tapered and parallel-cemented posts by using photoelastic stress analysis, the results generally favor the parallel-cemented posts. However, the evidence is mixed when the comparison between tapered and parallel posts is based on fracture patterns in extracted teeth created by applying a force via a mechanical testing machine.

When evaluating the combined data from multiple clinical studies, threaded posts generally produced the highest root fracture incidence (7\%) compared with tapered cemented posts (2\%) and parallel cemented posts (1\%). Analysis of individual clinical studies as opposed to the combined data produces less conclusive results. Additional comparative clinical studies would be beneficial, including designs that have not yet been evaluated in comparative studies.

**What Is the Proper Length for a Post?**

A wide range of recommendations have been made regarding post length, which includes the following:

1. The post length should equal the incisocervical or occlusocervical dimension of the crown.\textsuperscript{76–83}
2. The post should be longer than the crown.\textsuperscript{84}
3. The post should be one-third of the crown length.\textsuperscript{85}
4. The post should be half of the root length.\textsuperscript{86,87}
5. The post should be two-thirds of the root length.\textsuperscript{88–92}
6. The post should be four-fifths of the root length.\textsuperscript{93}
7. The post should be terminated halfway between the crestal bone and the root apex.\textsuperscript{94–96}
8. The post should be as long as possible without disturbing the apical seal.\textsuperscript{60}

A review of scientific data provides the basis for differentiating between these varied guidelines.

While short posts have never been advocated, they have been frequently observed during radiographic examinations (Figures 8 and 9). Grieve and
McAndrew\textsuperscript{97} found that only 34\% of 327 posts were as long as the incisocervical length of the crown. In a clinical study of 200 endodontically treated teeth, Ross\textsuperscript{75} determined that only 14\% of posts were two-thirds or more of the root length and 49\% of the posts were one-third or less of the root length. A radiographic study of 217 posts determined that only 5\% of the posts were two-thirds to three-fourths of the root length.\textsuperscript{98} In a retrospective clinical study of 52 posts, Turner\textsuperscript{44} radiographically compared the length of the post with the maximal length available if 3 mm of gutta-percha was retained. Posts that came loose used only 59\% of the ideal length and only 37\% of the posts were longer than the proposed maximal length. Nine millimeters was proposed as the ideal length. Short posts have been associated with higher root stresses\textsuperscript{36,64,66,70,71} and a greater tendency for root fracture to occur.

Sorensen and Martinoff\textsuperscript{46} determined that the clinical success was markedly improved when the post was equal to or greater than that of the crown length. Johnson and Sakumura\textsuperscript{99} determined that posts that were three-fourths or more of the root length were up to 30\% more retentive than posts that were half of the root length or equal to the crown length. Leary et al.\textsuperscript{100} indicated that posts with a length at least three-fourths of the root offered the greatest rigidity and least root bending.

These data indicate that post length would appropriately be three-fourths that of the root length. However, some interesting results occur when post length guidelines of two-thirds to three-fourths of the root length are applied to teeth with average, long, and short root lengths. It was determined that a post approaching this recommended length range is not possible without compromising the apical seal by retaining less than 5 mm of gutta-percha.\textsuperscript{101} When post length was half that of the root, the apical seal was rarely compromised on average length roots. However, when posts were two-thirds of the root length, many of the average and short roots would have less than the optimal gutta-percha seal. Shillingburg et al.\textsuperscript{102} also indicated that making the post length equal to the clinical crown length can cause the post to encroach on the 4-mm “safety zone” required for an apical seal.

Abou-Rass et al.\textsuperscript{103} proposed a post length guideline for maxillary and mandibular molars based on the incidence of lateral root perforations when post preparations were made in 150 extracted teeth. They determined molar posts should not be extended more than 7 mm apical to the root canal orifice.

When teeth have diminished bone support, stresses increase dramatically and are concentrated in the dentin near the post apex.\textsuperscript{104} A recent finite element model study established a relationship between post length and alveolar bone level.\textsuperscript{105} To minimize stress in the dentin and in the post, the post should extend more than 4 mm apical to the bone.

**CONCLUSIONS**

Reasonable clinical guidelines for length include the following:

1. Make the post approximately three-fourths of the length of the root when treating long-rooted teeth.
2. When average root length is encountered, post length is dictated by retaining 5 mm of apical gutta-percha and extending the post to the gutta-percha (Figure 10).
3. Whenever possible, posts should extend at least 4 mm apical to the bone crest to decrease dentin stress.
4. Molar posts should not be extended more than 7 mm into the root canal apical to the base of the pulp chamber (Figure 11).

How Much Gutta-Percha Should Be Retained to Preserve the Apical Seal?

It has been determined that when 4 mm of gutta-percha was retained, only 1 of 89 specimens showed leakage, whereas 32 of 88 specimens leaked when only 2 mm of gutta-percha was retained. Two studies found no leakage at 4 mm, and two additional studies found little leakage at 4 mm. Portell et al. found that most specimens with only 3 mm of apical gutta-percha had some leakage. When the leakage associated with 3, 5, and 7 mm of gutta-percha was compared, Mattison et al. found significant leakage differences between each of the dimensions. They proposed that at least 5 mm of gutta-percha is required for an adequate apical seal. Nixon et al. compared the sealing capabilities of 3, 4, 5, 6, and 7 mm of apical gutta-percha using dye penetration. The greatest leakage occurred when only 3 mm was retained, and it was significantly different from the other groups. They also noted a significant decrease in leakage when 6 mm of gutta-percha remained. Raiden and Gendelman cemented stainless steel posts with zinc phosphate cement in teeth with residual root canal fillings of 1, 2, 3, and 4 mm. They tested apical leakage using a passive dye system. They concluded that 4 mm of apical seal provided a leakage value of zero. Kvist et al. examined radiographs from 852 clinical endodontic treatments. Posts were present in 424 of the teeth. Roots with posts in which the remaining root filling material was shorter than 3 mm showed a significantly higher frequency of periapical radiolucencies. Using a pressure-driven tracer assay, Wu et al. and Abramovitz et al. found that 4 or 5 mm of apical seal was inferior in their ability to prevent leakage, compared with an original full-length root canal filling. Similarly, Metzger et al. compared the sealing capabilities of 3, 5, 7, and 9 mm of apical gutta-percha using a pressure-driven radioactive tracer assay. They concluded that the sealing is proportional to the length of the remaining filling and that original full-length root canal fillings have a superior seal compared with 3, 5, and 7 mm of apical gutta-percha.
CONCLUSIONS
Since there is greater leakage when only 2 to 3 mm of gutta-percha is present (Figure 12), 4 to 5 mm should be retained apically to ensure an adequate seal. Although studies indicate that 4 mm produces an adequate seal, stopping precisely at 4 mm is difficult and radiographic angulation errors could lead to retention of less than 4 mm. Therefore, 5 mm of gutta-percha should be retained apically. This seal is complemented by the seal provided by the post and core, and the overlying crown (Figure 11).

Does Post Diameter Affect Retention and the Potential for Tooth Fracture?
Studies relating post diameter to post retention have failed to establish a definitive relationship. Two studies determined that there was an increase in post retention as the diameter increased, whereas three studies found no significant retention changes with diameter variations. Krupp et al. indicated that post length was the most important factor affecting retention and post diameter was a secondary factor.

A more definitive relationship has been established between post diameter and stress in the tooth. Mattison found that as the post diameter increased, stress increased in the tooth. Trabert et al. measured the impact resistance of extracted maxillary central incisors as post diameter increased and found that increasing the post diameter decreased the tooth’s resistance to fracture. Deutsch et al. determined that there was a six-fold increase in the potential for root fracture with every millimeter decrease in tooth diameter. However, two finite element studies failed to find higher tooth stresses with larger-diameter posts.

CONCLUSIONS
Laboratory studies relating retention to post diameter have produced mixed results, whereas a more definitive relationship has been established between root fracture and large-diameter posts (Figure 13).

Figure 12 Less than 2 mm of gutta-percha remains in the maxillary first premolar apical to the cast post and core, increasing the risk of failure.

Figure 13 Excessive post diameters. A. Large-diameter post placed in the palatal root of the maxillary molar. B. Large-diameter threaded post caused fracture of the maxillary second premolar. The radiographic appearance of the bone is typical of a fractured root—a teardrop-shaped lesion with diffuse border.
What Is the Relationship Between Post Diameter and the Potential for Root Perforations?

In a literature review of guidelines associated with post diameter, Lloyd and Palik indicated that there are three distinct philosophies of post space preparation. One group advocates the narrowest diameter for fabrication of a certain post length (the conservationists). Another group proposes a space with a diameter that does not exceed one-third of the root diameter (the proportionists). The third group advises leaving at least 1 mm of sound dentin surrounding the entire post (the preservationists).

Based on the proportional concept of one-third of the root diameter, three articles measured the root diameters of extracted teeth and proposed post diameters that would not exceed this proportion. Tilk et al. examined 1,500 roots. They measured the narrowest mesiodistal dimension at the apical, middle, and cervical one-thirds of the teeth except the palatal root of the maxillary first molar that was measured faciolingually. Based on the 95% confidence level that post width would not exceed one-third of the apical width of the root, they proposed the following post widths (Table 6): small teeth such as mandibular incisors (0.6 to 0.7 mm); large-diameter roots such as maxillary central incisors and the palatal root of the maxillary first molar (1.0 mm); and for the remaining teeth (0.8 to 0.9 mm).

Shillingburg et al. measured 700 root dimensions to determine the post diameters that would minimize the risk of perforation. Also based on not exceeding one-third of the mesiodistal root width, they recommended the following post diameters (see Table 6): mandibular incisors (0.7 mm); maxillary central incisors or other large roots (1.7 mm—which was the maximal recommended dimension); post tip diameter (at least 1.5 mm less than the root diameter at that point); and post diameter at the middle of the root length (2.0 mm less than the root diameter).

Post spaces were prepared in 150 extracted maxillary and mandibular molars by using different instrument diameters and the resulting incidences of perforations were recorded. The authors determined that the mesial roots of mandibular molars and the buccal roots of maxillary molars should not be used for posts due to the higher risk of perforation on the furcation side of the root. For the principal roots (mandibular distal and maxillary palatal), they determined that posts should not be extended more than 7 mm into the root canal (apical to the pulp chamber) due to the risk of perforation. Regarding instrument size, they concluded that post preparations can be safely completed by using a No. 2 Peeso instrument, but perforations are more likely when the larger Nos. 3 and 4 Peeso instruments are used.

Raiden et al. evaluated several instrument diameters (0.7, 0.9, 1.1, 1.3, 1.5, and 1.7 mm) to determine which one(s) would preserve at least 1 mm of root wall thickness following post preparation in maxillary first premolars. They determined that instrument diameter must be small (0.7 mm or less) for maxillary first premolars with single canals because the mesial and distal developmental root depressions restrict the amount of available tooth structure in the centrally located single root canal. However, when there are dual canals, the instrument can be as large as 1.1 mm because the canals are located buccally and lingually into thicker areas of the roots.

CONCLUSIONS

Instruments used to prepare posts should be related in size to root dimensions to avoid excessive post diameters that lead to root perforation (Figure 14). Safe instrument diameters to use are 0.6 to 0.7 mm for small teeth such as mandibular incisors and 1 to

<table>
<thead>
<tr>
<th>Table 6 Post Space Preparation Widths (in Millimeters)</th>
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<tbody>
<tr>
<td>Maxillary</td>
</tr>
<tr>
<td>Tilk et al  Shillingburg et al  Tilk et al  Shillingburg et al</td>
</tr>
<tr>
<td>Central incisor 1.1 1.7 0.7 0.7</td>
</tr>
<tr>
<td>Lateral incisor 0.9 1.3 0.7 0.7</td>
</tr>
<tr>
<td>Canine 1.0 1.5 0.9 1.3</td>
</tr>
<tr>
<td>First premolar (B) 0.9 0.9</td>
</tr>
<tr>
<td>(L) 0.9 0.9</td>
</tr>
<tr>
<td>Second premolar 0.9 1.1 0.9 1.3</td>
</tr>
<tr>
<td>First molar (MB) 0.9 1.1 (MB) 0.9 1.1</td>
</tr>
<tr>
<td>(DB) 0.8 1.1 (ML) 0.8 0.9</td>
</tr>
<tr>
<td>(L) 1.0 1.3 (D) 0.9 1.1</td>
</tr>
<tr>
<td>Second molar (MB) - 1.1 (MB) - 0.9</td>
</tr>
<tr>
<td>(DB) - 0.9 (ML) - 0.9</td>
</tr>
<tr>
<td>(L) - 1.3 (D) - 1.1</td>
</tr>
</tbody>
</table>
1.2 mm for large-diameter roots such as the maxillary central incisors. Molar posts longer than 7 mm have an increased chance of perforations and therefore should be avoided even when using instruments of an appropriate diameter.

**Can Gutta-Percha Be Removed Immediately after Endodontic Treatment and a Post Space Prepared?**

Several studies indicate that there is no difference in the leakage of the root canal filling material when the post space is prepared immediately after completing endodontic therapy. Bourgeois and Lemon found no difference between immediate preparation of a post space and preparation 1 week later when 4 mm of gutta-percha were retained. Zmener found no difference in dye penetration between gutta-percha removal after 5 minutes and 48 hours. Two sealers were tested and 4 mm of gutta-percha was retained apically. When lateral condensation of gutta-percha was used, Madison and Zakariasen found no difference in the dye penetration between immediate removal and 48-hour removal. Using the chloropercha filling technique, Schnell found no difference between immediate removal of gutta-percha and no removal of gutta-percha. By contrast, Dickey et al. found significantly greater leakage with immediate gutta-percha removal.

Kwan and Harrington tested the effect of immediate gutta-percha removal using both warm instruments and rotary instruments. There was no significant difference between the controls and immediate removal using warm pluggers and files. Compared with the controls, there was significantly less leakage with immediate removal of gutta-percha when using Gates Glidden drills.

Karapanou et al. compared immediate and delayed removal of two sealers (a zinc oxide–eugenol-based sealer and a resin-based sealer). No difference between immediate and delayed removal was noted with the resin-based sealer, but delayed removal of the zinc oxide–eugenol-based sealer produced significantly greater leakage. Abramovitz et al. compared immediate gutta-percha removal using hot pluggers and delayed gutta-percha removal (after 2 weeks) using Gates Glidden drills. They found no difference between the two methods.

Portell et al. found that delayed gutta-percha removal (after 2 weeks) caused significantly more leakage than immediate removal when only 3 mm of gutta-percha was retained apically. Fan et al. found more leakage from delayed removal of gutta-percha. Solano et al. found a less significant difference in apical leakage between teeth whose post spaces were prepared at the time of the obturation and 1 week later using warm gutta-percha condensation and AH Plus sealer.

**CONCLUSIONS**

Adequately condensed gutta-percha can be safely removed immediately after endodontic treatment.

**What Instruments Remove Gutta-Percha Without Disturbing the Apical Seal?**

Three methods have been advocated for the removal of gutta-percha during preparation of a post space: chemical (oil of eucalyptus, oil of turpentine, and chloroform), thermal (electrical or heated instruments), and mechanical (Gates Glidden drills, Peeso reamers, etc.). The chemical removal of gutta-percha for post space preparation is not utilized for specific reasons (microleakage, inability to control removal). However, thermal and mechanical
techniques or a combination of both are routinely used.

Multiple studies have determined that there is no difference in leakage between removing gutta-percha with hot instruments and removing it with rotary instruments. Suchina and Ludington and Mattison et al. found no difference between hot instrument removal and removal with Gates Glidden drills. Camp and Todd found no difference between Peeso reamers, Gates Glidden drills, and hot instruments. Hiltner et al. compared warm plugger removal with two types of rotary instruments (GPX burs and Peeso reamers). There were no significant differences in dye leakage between any of the groups. Contrasting results were found by Haddix et al. They measured significantly less leakage when gutta-percha was removed with a heated plugger than when either a GPX instrument or Gates Glidden drills were used. DeCleen found that it is desirable to remove gutta-percha using a heated instrument first, and then using a small Gates Glidden drill. Using a pressure-driven radioactive tracer assay, Abramovitz et al. found no difference in apical leakage between hot pluggers and Gates Glidden drills. Balto et al. compared two methods of gutta-percha removal and their impact on apical leakage. They found that removing gutta-percha with Peeso reamers showed less leakage compared with using a hot plugger.

CONCLUSIONS
Both rotary instruments and hot hand instruments can be safely used to remove adequately condensed gutta-percha when 5 mm is retained apically.

Can a Separated Instrument Be Removed During Post Space Preparation and Still Maintain the Apical Seal?
Following root canal therapy, the endodontically treated tooth could present with a separated instrument (files, rotary instruments, etc.) in any part of the canal. Attempts to remove these fragments prior to post space preparation could lead to loss of apical seal, perforations, ledge formation, and/or over enlargement of the canal. A decision to bypass or remove the fragment will depend on the type and position of the broken instrument and should be determined by an endodontist with the use of an operating microscope.

Bypassing fractured instruments seems to be the best approach. Hülsman and Schinkel reported an overall success rate of 68% when bypassing broken instruments from canals in vivo. Ward et al. reported an overall success rate of 73%. Suter et al. with the use of an dental operating microscope were able to achieve an overall success rate of 87% when removing broken instruments.

CONCLUSIONS
If a separated fragment of any instrument cannot be removed from the canal during post space preparation, it should be bypassed or left in the canal.

Can a Portion of a Silver Point Be Removed and Still Maintain the Apical Seal?
In one study, all the specimens leaked when 1 mm of a 5-mm long silver point was removed by using a round bur. Neagley found that removal of the filling material coronal to the silver point with a Peeso reamer caused no leakage. However, when all the filling materials and 1 mm of the silver point were removed, complete dye penetration occurred in eight of nine specimens.

CONCLUSIONS
The removal of a portion of a silver point during post preparation causes apical leakage.

How Soon should the Definitive Restoration Be Placed After Post Space Preparation?

ONE-PIECE PROVISIONAL RESTORATION
It is well established that a deficient root canal obturation and a poor coronal restoration will potentially allow endotoxins, bacteria, and saliva to penetrate the root canal causing periapical inflammation. Provisional restorations are mainly used to provide the patient with a functional and aesthetic restoration. They also protect the hard and soft tissues prior to placement of the definitive restoration. However, provisional restorations are considered restorations with poor coronal seal. Several studies indicate that there is significant coronal leakage when the tooth is restored.
with a provisional restoration. Demarchi et al. found that a tooth restored with a temporary post-crown combination had significantly greater leakage than definitively cemented prefabricated posts and separate crowns. Similar results were found by Fox et al. when they compared cast posts and cores cemented with zinc phosphate cement, prefabricated posts and composite resin cores cemented with resin cement, and provisional post-crowns cemented with zinc oxide–eugenol cement. In a 3-year retrospective clinical study, Lynch et al. evaluated 176 endodontically treated teeth. They found that the loss of endodontically treated teeth occurred more often with those teeth restored with provisional restorations. Following these results, several studies suggested that the definitive post and restoration should be cemented as soon as possible to prevent recontamination of the root canal. However, to minimize leakage and enhance long-term success, the definitive coronal restoration should be of superior quality.

**CONCLUSIONS**

Following endodontic treatment, post space preparation should be performed and a post definitively cemented as soon as possible: the same day for a prefabricated post, and as soon as possible for a custom-fabricated post and core. The prepared tooth should then be restored with a well-fitting provisional restoration (good marginal seal and occlusion) followed by cementation of the definitive crown in as short a time as possible.

**Does the Use of a Cervical Ferrule that Engages Tooth Structure Help Prevent Tooth Fracture?**

Survey data have been published that indicate the percentage of respondents who felt a ferrule (circumferential band of metal) increased a tooth’s resistance to fracture. Fifty-six percent of general dentists, 67% of prosthodontists, and 73% of board-certified prosthodontists felt that core ferrules increased a tooth’s fracture resistance. To investigate this concept, several research studies have been performed. Some of the articles found ferrules are beneficial whereas others found no increase in fracture resistance. The results appear indecisive until differences between study designs are analyzed. First, some of the studies tested ferrules that were part of a cast metal core (core ferrules), whereas other studies evaluated the effectiveness of ferrules created by the overlying crown engaging tooth structure. One study evaluated both core ferrules and crown ferrules. Second, there were differences in the form of the ferrule, and therefore, the manner by which the metal engaged tooth structure (beveled sloping surface versus extension over relatively parallel prepared tooth structure). Third, there were variations in the amount of tooth structure encompassed by the restoration leads to a high success rate of endodontically treated teeth. Contrasting results were reported by Tronstad et al. who found that the quality of the endodontic treatment was significantly more important than that of the coronal restoration.
The data generally indicate that ferrules formed as part of the core are less effective than ferrules created when the overlying crown engages tooth structure. In four of the six core ferrule studies, they were found to be ineffective.\textsuperscript{159,160,162,177} Also, in one of the two studies where the core ferrule was effective, the ferrule form was a 2-mm parallel extension of the core over tooth structure as opposed to a bevel.\textsuperscript{158} In the other study where core ferrules were found to be effective, a torsional force was used as opposed to an angular lingual force.\textsuperscript{161} In the crown ferrule studies, most of the ferrules effectively increased a tooth's resistance to fracture. Only when the crown ferrule was of minimal dimension or had a sloping form, it was found to be ineffective.\textsuperscript{163,177} In support of these studies, Rosen and Partida-Rivera\textsuperscript{178} found that a 2-mm cast gold collar (not part of the post and core) was very effective in preventing root fracture when a tapered screw post was intentionally threaded into roots so as to induce fracture. Assif et al.\textsuperscript{179} found no difference in the tooth fracture patterns of parallel posts, tapered posts, and parallel posts with a tapered end when they were covered by a crown that grasped 2 mm of tooth structure. Akkayan et al.\textsuperscript{170} found no significant difference between fiber-reinforced and zirconia dowels when the ferrule length was 2 mm.

The data also support the concept that ferrules that grasp larger amounts of tooth structure are more effective than those engaging only a small amount of tooth structure. In both the core and crown ferrule studies, the tooth's resistance to fracture was increased when a substantive amount of tooth structure was engaged (2 mm in the core ferrule studies and 1 to 2 mm in the crown ferrule studies). Libman and Nicholls\textsuperscript{163} found the 0.5- to 1.0-mm crown ferrule to be ineffective whereas a 1.5- to 2.0-mm crown ferrule to be effective. Isidor et al.\textsuperscript{165} determined that increasing the crown ferrule length significantly increased the number of cyclic cycles required to cause specimen failure. They compared no ferrule with 1.25 and 2.55 mm crown ferrules. They concluded that

<table>
<thead>
<tr>
<th>Study</th>
<th>Ferrule Form</th>
<th>Was Ferrule Effective?</th>
<th>Materials/Type of Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barkhordar (1989)</td>
<td>2 mm parallel extension of core over the tooth</td>
<td>Yes</td>
<td>Extracted teeth/angular lingual force applied to p and c (no overlying crown)</td>
</tr>
<tr>
<td>Sorensen (1990)</td>
<td>1 mm wide 60° bevel at the tooth-core junction</td>
<td>No</td>
<td>Extracted teeth/angular lingual force applied to p and c (no overlying crown)</td>
</tr>
<tr>
<td>Tjan (1985)</td>
<td>60° bevel at the tooth-core junction</td>
<td>No</td>
<td>Extracted teeth/angular lingual force applied to p and c (no overlying crown)</td>
</tr>
<tr>
<td>Loney (1990)</td>
<td>1.5 mm parallel extension of core over the tooth</td>
<td>No</td>
<td>Photoelastic teeth/angular lingual force applied to p and c (no overlying crown)</td>
</tr>
<tr>
<td>Hemmings (1991)</td>
<td>45° bevel</td>
<td>Yes</td>
<td>Extracted teeth/torsional force applied to p and c (no overlying crown)</td>
</tr>
<tr>
<td>Sauer (1996)</td>
<td>2 mm parallel extension of core over thin dentin wall (0.5–0.75 mm thick)</td>
<td>No</td>
<td>Extracted teeth/angular lingual force applied to p and c (no overlying crown)</td>
</tr>
<tr>
<td>Sorensen (1990)</td>
<td>130° sloping finish line</td>
<td>No</td>
<td>Extracted teeth/p and c with crown/p and c with crown</td>
</tr>
<tr>
<td>Libman (1995)</td>
<td>0.5–1 mm of prepared tooth grasped by crown</td>
<td>No</td>
<td>Extracted teeth/p and c with crown/cyclic loading/p and c with crown</td>
</tr>
<tr>
<td>Milot (1992)</td>
<td>1 mm wide 60° bevel grasped by crown</td>
<td>Yes</td>
<td>Plastic analogues of teeth/p and c with crowns</td>
</tr>
<tr>
<td>Isidor (1999)</td>
<td>1.25 mm of prepared tooth grasped by crown</td>
<td>Yes</td>
<td>Bovine teeth/cyclic angular load/p and c with crown</td>
</tr>
<tr>
<td>Hoag (1982)</td>
<td>1–2 mm of prepared tooth grasped by crown</td>
<td>Yes</td>
<td>Bovine teeth/cyclic angular load/p and c with crown</td>
</tr>
<tr>
<td>Gegauff (2000)</td>
<td>2 mm of prepared tooth grasped by crown; 0 mm of prepared tooth grasped by a crown</td>
<td>Yes</td>
<td>Composite teeth/p and c with crown</td>
</tr>
</tbody>
</table>

Table 7 Comparison of Studies and Effectiveness of Various Core and Crown Ferrules
ferrule length was more important than post length in increasing a tooth’s resistance to fracture under cyclic loading. Zhi-Yue and Yu-Xing\textsuperscript{169} found that a 2-mm crown ferrule effectively enhanced the fracture strength of endodontically treated teeth when a cast post and core was used. Pereira et al.\textsuperscript{176} compared the effect of no crown ferrule with 1, 2, and 3-mm crown ferrules. They found that a 3-mm crown ferrule significantly increased the fracture resistance of endodontically treated teeth compared with a 2-mm crown ferrule.

The form of the prepared ferrule also appears to affect a tooth’s fracture resistance in the previously cited studies. Only one beveled/sloping ferrule was effective in enhancing a tooth’s fracture resistance and that was when a torsional force was applied to the tooth. Tan et al.\textsuperscript{172} compared a 2-mm uniform crown ferrule that extended around the entire crown circumference with a 2-mm nonuniform crown ferrule where the ferrule was only 0.5 mm on the proximal surfaces. The uniform ferrule produced significantly greater fracture resistance than a nonuniform ferrule. In an in vitro study, Naumann et al.\textsuperscript{173} evaluated the effect of chewing simulation on the fracture resistance of maxillary endodontically treated teeth with incomplete crown ferrules. The greatest variation of failure load was associated with the absence of portions (facial, palatal, or interproximal) of the crown ferrule. Ng et al.\textsuperscript{174} investigated the effect of limited residual axial tooth structure on the fracture resistance of maxillary anterior endodontically treated teeth. They found that in the absence of 360° of circumferential coronal tooth structure, the location of the remaining coronal tooth structure may be an important factor for determining the fracture resistance of endodontically treated teeth. The palatal axial wall was as effective as a 360° circumference in providing fracture resistance.

**CONCLUSIONS**

Differences of opinion exist regarding the effectiveness of ferrules in preventing tooth fracture. Ferrules have been tested when they are part of the core and also when the ferrule is created by the overlying crown engaging tooth structure. Most of the data indicate that a ferrule created by the crown encompassing tooth structure is more effective than a ferrule that is part of the post and core (Figure 15). Ferrule effectiveness is enhanced by grasping larger amounts of tooth structure. The amount of tooth structure engaged by the overlying crown appears to be more important than the length of the post in increasing a tooth’s resistance to fracture. Ferrules are more effective when the crown encompasses relatively parallel prepared tooth structure than when it engages beveled/sloping tooth surfaces. Ferrules that encompass 2 mm of tooth structure around the entire circumference of a tooth are more effective than nonuniform ferrules.

**Post and Core Placement Techniques**

**PRETREATMENT DATA REVIEW**

When it has been determined that a post and core is required to properly retain a definitive single crown or fixed partial denture, the following characteristics should be determined prior to beginning the clinical procedures associated with the fabrication of a post and core.

**POST LENGTH**

Since 5 mm of gutta-percha should be retained apically to ensure a favorable seal (as measured radiographically), posts should be extended to that length in all teeth except molars. With molars, posts should be placed in the primary roots (palatal root of maxillary molars and distal roots of mandibular molars) and should not be extended more than 7 mm apical to the origin of the root canal in the base of the pulp chamber (Figure 11). Extension beyond this length can lead to root perforation or only very thin areas of remaining tooth structure.
POST DIAMETER
A frequently used and clinically appropriate guideline for post diameter is not to exceed one-third of the root diameter. It has been determined that when a root canal is prepared for a post and the diameter is increased beyond one-third of the root diameter, the tooth becomes exponentially weaker. Each millimeter increase (beyond one-third of the root diameter) causes a six-fold increase in the potential for root fracture. Based on measuring the root dimensions of 1,500 teeth (125 for each tooth) and using the guideline that the post should be one-third of the root diameter, optimal post diameter measurements have been determined to be approximately 0.6 mm for mandibular incisors, 1.0 mm for maxillary central incisors, maxillary and mandibular canines, and the palatal root of the maxillary first molar. The recommended post diameter for the other teeth was 0.8 mm. Another study of 700 teeth recommended that post diameter should range from 0.7 mm for mandibular incisors to a maximum of 1.7 mm for maxillary central incisors.

ANATOMICAL/STRUCTURAL LIMITATIONS
The practitioner who completed the endodontic treatment is ideally suited to identify characteristics of the pulp chamber, rooted canal(s) anatomy, and completed endodontic filling that should be reviewed before placing a post and core. These characteristics include the presence and the extent of dentinal craze lines, identification of teeth where further root preparation (beyond that needed to complete endodontic instrumentation) will result in less than 1 mm of remaining dentin or a post diameter greater than one-third of the root diameter area, information regarding areas where the remaining tooth structure is thin, and the point at which significant root curvature begins.

CRAZE LINES
Cracks in dentin are areas of weakness where further propagation may result in root fracture and tooth loss (see Chapter 19). The patient should be informed of their presence with appropriate chart documentation of crack location. It is prudent to avoid post placement, if possible, in favor of a restorative material core. If a post is required, it should passively fit the canal, and the definitive restoration should entirely encompass the cracked area, whenever possible, by forming a ferrule.

DENTIN THICKNESS AFTER ENDOdontIC TREATMENT
Following normal and appropriate endodontic instrumentation, teeth can possess less than 1 mm of dentin, indicating that there should be no further root preparation for the post. When these teeth are encountered, it is best to fabricate a post that fits into the existing morphological form and diameter rather than additionally preparing the root to accept a prefabricated type of post. This characteristic is one of the primary indications for the use of a custom cast post and core. One study determined that canines (maxillary and mandibular), maxillary central and lateral incisors, and the palatal root of maxillary first molars possessed more than 1 mm of dentin after endodontic cleaning and shaping. All other teeth had roots with less than 1 mm of remaining dentin following endodontic treatment. With the goal of preserving 1 mm of remaining dentin lateral to posts, it has been determined that single-canal maxillary first premolars should have posts that are 0.7 mm in diameter or less. Mandibular premolars with oval/ribbon-shaped canals should not be subjected to any preparation of the root canal for a post since it will result in less than 1 mm of dentin. Preparation of the mesial root canals in mandibular molars and the facial root canals in maxillary molars can result in perforation or only thin areas of remaining dentin. Based on the measurements of residual dentin thickness, it is recommended that posts not be placed in these roots if possible.

ROOT CURVATURE
When root curvature is present, post length must be limited so as to preserve remaining dentin, thereby helping to prevent root fracture or perforation. Root curvature occurs most frequently in the apical 5 mm of the root. Therefore, if 5 mm of gutta-percha is retained apically, curved portions of the root are usually avoided. As discussed previously under post length, molar posts should not exceed 7 mm in the roots because of the potential for perforation due to root curvature and the presence of developmental root depressions. Molar roots are frequently curved and the post should terminate at the point where substantive curvature begins.

TYPE OF POST AND CORE
Custom Cast Post
For many years, custom cast posts and cores have been considered to be the standard of care when restoring
endodontically treated teeth and have historically been made of metal. Gold, silver–palladium, and base metal alloys are the most commonly used metals. For economic reasons, base metal alloys were introduced as an alternative metal to high-noble alloys. The major disadvantages of base metal alloys are their manipulation (laboratory and clinical), their hardness, and their unstable chemical structure. The degradation of base metal alloys releases substances that could be harmful to the patient. Silver–palladium alloys were introduced as a replacement for gold and base metal alloys. They are relatively easy to manipulate and have many properties similar to those of gold casting alloys. However, the castability of silver–palladium alloys was shown to be inferior to that of gold-based alloys.

Cast posts and cores can be fabricated by using either a direct or an indirect technique, and several methods have been described for the intraoral fabrication of an acrylic resin pattern for a direct post and core. Prefabricated plastic patterns are commonly used, and they are relined to fit the post space with an autopolymerizing acrylic resin (Figure 16). The coronal adaptation of the tooth is usually completed by using the same resin, and the core is contoured intraorally to the desired form. The only disadvantage of this direct technique is the amount of chairside time required to perform the procedure.

As an alternative, indirect techniques for the fabrication of cast posts and cores have been proposed. However, this procedure requires meticulous attention to a defined protocol to ensure success. One technique uses a Lentulo spiral instrument to carry an impression material to the apical aspect of the prepared post space. Since a thin projection of a polymerized impression material can be distorted or torn upon removal from the mouth, reinforcement of the impression material is required. This reinforcement can be accomplished by using several materials such as a plastic pin or a metal wire. Care must be taken when using plastic pins to ensure that they are not slightly flexed by placement into a curved canal or through contact with the impression tray, thereby allowing a return to their original form upon impression removal with some resulting distortion. The use of a portion of a safety pin is an excellent material so long as it is made of spring steel, thereby preventing flexion. A bendable metal pin can be distorted upon impression removal. Complete seating of a section from a safety pin until it contacts the gutta-percha is recommended. Upon removal of the impression from the mouth, the presence of the metal pin at the apical extension of the impression material indicates that there was no elongation of the impression material upon removal.

To make the impression technique easier, prefabricated precision plastic dowels were introduced. After the selection of the desired diameter for the dowel, a corresponding drill is used to prepare the post space at the appropriate length. The dowel is then inserted into the prepared canal, picked up in an impression, and transferred to the dental laboratory for fabrication.

A proposed advantage of cast posts and cores is their purported ease of removal in case of an endodontic retreatment. In addition, several long-term clinical studies have reported high success rates with cast post and cores.

Prefabricated Posts
Prefabricated posts have become quite popular and a wide variety of systems are available: parallel-sided or tapered, smooth or serrated, passive (cement/bonded) or active (threaded), or combinations of these. Threaded posts depend primarily on engaging the tooth—either through threads formed in the dentin as
the post is screwed into the root or through threads previously “tapped” into the dentin. The majority of these posts are metallic. Recently, in response to a need for tooth-colored posts, several nonmetallic posts such as carbon fiber epoxy resin, zirconia, glass fiber-reinforced (GFR) epoxy resin, and ultrahigh strength polyethylene fiber-reinforced (PFR) posts are available and early data indicates that they can be acceptable alternatives to metallic posts.

The carbon fiber-reinforced (CFR) epoxy resin post system was developed in France in 1988 by Duret and Renaud\(^\text{205–207}\) and first introduced in Europe in the early 1990s.\(^\text{208–210}\) The matrix for this post is an epoxy resin reinforced with unidirectional carbon fibers parallel to the long axis of the post. The fibers are 8 µm in diameter and uniformly embedded in the epoxy resin matrix. By weight, the fibers comprise 64% of the post and are stretched before injection of the resin matrix to maximize the physical properties of the post (Figure 17).\(^\text{205,211,212}\) The post is reported to absorb applied stresses and distribute these stresses along the entire post channel.\(^\text{213}\) The bulk of the carbon fibers is made from polyacrylonitrile by heating it in air at 200\(^\circ\)C to 250\(^\circ\)C and then in an inert atmosphere at 1200\(^\circ\)C. This process removes hydrogen, nitrogen, and oxygen, leaving a chain of carbon atoms and forming carbon fibers.\(^\text{214}\)

The CFR post has been reported to exhibit high fatigue strength, high tensile strength, and a modulus of elasticity similar to dentin.\(^\text{208,211,215–218}\) The post was originally radiolucent; however, a radiopaque post is now available. Radiopacity is produced by placing traces of barium sulfate and/or silicate inside the post. Mannocci et al.\(^\text{219}\) examined radiographically five different types of fiber posts. They found that only Composipost and Snowpost posts had uniform radiopacity. Finger et al.\(^\text{220}\) examined the radiopacity of seven fiber-reinforced resin posts compared with a titanium post. Compared to other posts, they found CFR posts had an acceptable radiopacity.

The posts are available in different shapes: double cylindrical with conical stabilization ledges or conical shapes (Figure 18). The surface texture of the post may be smooth or serrated. Studies have indicated that serrations increased mechanical retention although the smooth post also bonded well to adhesive dental resin.\(^\text{217,221}\) The post has a surface roughness of 5 to 10 µm to enhance mechanical adhesion of the autopolymerizing luting material, and the post appears to be biocompatible based on cytotoxicity tests.\(^\text{216,222}\)

Several studies indicate that CFR posts exhibit adequate physical properties compared to metal posts.\(^\text{212,215,223,224}\) In a retrospective study over 4 years, Ferrari et al.\(^\text{223}\) indicated that the Cosmopost system was superior to the conventional cast post and core system. King and Setchell\(^\text{215}\) and Duret et al.\(^\text{212}\) evaluated the physical properties (fracture resistance and modulus of elasticity) of CFR posts and both
reported that these posts are stronger than prefabricated metal posts.

Contrasting results were reported by Sidoli et al. in an in vitro study. They found that CFR posts exhibited inferior strength when compared with metallic posts. Similar results were also obtained by Purton and Love and Asmussen et al.

Martinez-Insua et al. studied the fracture resistance of teeth restored with CFR posts and cast posts. They reported a significantly higher fracture threshold for cast post and cores. A clinical evaluation of CFR posts suggested that these posts did not perform as well as conventional cast post and cores. However, the results of this study must be interpreted with caution because of the relatively small sample size (27 teeth) used in this study.

Multiple studies indicate that there is a decrease in the strength of CFR posts after thermocycling and cyclic loading. In addition, contact of the post with oral fluids reduced their flexural strength values.

In two studies, results indicated no significant difference among a CFR post, cast post and cores, and metal posts when restoring mandibular incisor teeth. No differences were noted in the mode or state of fracture observed.

Multiple in-vitro studies have reported that CFR posts are less likely to cause fracture of the root at failure. The mode of failure of teeth restored with CFR posts in these studies was more favorable to the remaining tooth structure.

However, despite all these advantageous properties, in vivo applications of the CFR post should be questioned. When the ferrule is small or absent in an endodontically treated tooth restored with a CFP post, loads may cause the post to flex causing a micromovement of the entire core. The cement seal at the margin of the crown can be compromised, accompanied by microleakage of oral bacteria and fluids. As a result, secondary caries may develop in the space and may not be easily detected.

The short-term clinical studies of CFR posts appear promising but some of the longer-term studies report higher failure rates. Wenström restored 173 teeth with CFR posts and reported two failures after a period of 3 to 4 years. A short-term retrospective study of 236 teeth treated 2 to 3 years previously reported no failures of the posts. Ferrari et al. studied 100 CFR posts and reported a failure rate of 3.2% after a mean time of 3.8 years of clinical service. In a prospective study of 59 CFR posts, Glazer et al. indicated that these posts did not fracture and there was a 7.7% absolute failure rate. Another retrospective study of 1,304 CFR posts followed from 1 to 6 years found a 3.2% failure rate that was attributed to debonding during removal of temporary crowns and periapical lesions. Hedlund et al. studied the clinical performance of 63 CFR posts for an average of 2.3 years of clinical service and found a 3% failure rate. In a retrospective study of 64 CFR posts, Segerström et al. found that nearly 50% of the CFR posts were lost after a mean time of 6.7 years.

Should fracture of a CFR post occur, a potential advantage is the relative ease of removal from the post space compared with metal posts. A removal kit has been suggested for this procedure and the latter is recommended as a single use only item.

**Glass fiber-reinforced epoxy resin posts** The high demand for esthetic restorations and all-ceramic crowns led to the development of a variety of tooth-colored post systems as an alternative to metal and CFR posts.

The GFR epoxy resin post is made of glass or silica fibers (white or translucent). Glass fiber posts can be made of different types of glasses: electrical glass, high-strength glass, or quartz fibers (Figure 19). The commonly used fibers are silica-based (50% to 70% SiO₂), in addition to other oxides.

![Figure 19 Surface texture of a glass fiber-reinforced epoxy resin post (SEM magnification: x250).](image)
The GFR post is available in different shapes: cylindrical, cylindroconical, or conical shape (Figure 20). An in vitro assessment of several GFR post systems indicated that parallel-sided GFR posts are more retentive than tapered GFR posts.254

The composition of the glass fibers in the matrix tends to play an important role in the strength of the post. Newman et al.232 compared the fracture resistance of two GFR posts containing different weight percentages of glass fibers. They found that the higher content of glass fibers in the post contributed to the greater strength displayed by the tested post.

The GFR post has been reported to exhibit high fatigue strength, high tensile strength, and a modulus of elasticity closer to dentin than that of CFR posts.218,227,255 The GFR post is as strong as the CFR post and approximately twice as rigid.256

The flexural strength of GFR posts is not related to the type of glass fiber used. Galhano et al.218 evaluated the flexural strength of carbon fiber, quartz fiber, and glass fiber posts. They found that the posts behaved similarly because of the same concentration and type of the epoxy resin used to join the fibers together. Pfeiffer et al.257 evaluated, in vitro, the yield strength of GFR post, titanium, and zirconia posts. They found that the yield strength was significantly higher for the zirconia and titanium posts when compared with GFR posts.

Several studies have determined that there is a decrease in the strength (about 40%) of GFR posts after thermocycling and cyclic loading. In addition, contact of the post with oral fluids (short- and long-term) reduced their flexural strength.230,233,258–260

Two studies indicated that the tensile bond strength between the composite resin core material and the GFR post is less than that developed with a titanium post.261,262 Other studies indicated that there was a good adhesive bond between the GFR post and composite resin cements.261,263,264 The bonding of the core to the post can be improved by treating the post with airborne-particle abrasion.265 Similar results were obtained by treating the surface of the post with hydrogen peroxide and silane or hydrofluoric acid and silane.266,267 During fatigue loading, a composite resin core bonded to a GFR post provided significantly stronger crown retention than cast gold posts and cores and titanium posts with composite resin cores.171

Similar to CFR posts, multiple studies have shown that GFR posts are less likely to cause fracture of the root at failure.232,268–270 The mode of failure of teeth restored with CFR posts in these studies was more favorable to the remaining tooth structure. However, studies have discussed the importance of the presence of a ferrule effect in achieving a high success rate.170,175,174,271 Malferri et al.270 restored 180 teeth with GFR posts and reported no post, core, or root fracture after 30 months of service. Naumann et al.272 found that the survival rate of parallel-sided and tapered GFR posts was similar.

Polyethylene fiber-reinforced posts (PFR) are made of ultrahigh molecular weight polyethylene-woven fiber ribbon (Ribbon, Ribbon Inc., Seattle, WA). They are not posts and cores in the traditional sense. The post is a polyethylene-woven fiber ribbon that is coated with a dentin bonding agent and packed into the canal, where it is then light polymerized in position.273–275 The Ribbon material has a three-dimensional structure due to either a leno weave or a triaxial architectural design. These designs are composed of a great number of nodal intersections that prevent crack propagation and provide a mechanical retention for the composite resin cement. When PFR posts were compared with metal posts in the laboratory, the fiber-reinforced posts reduced the incidence of vertical root fracture. The addition of a small-size prefabricated post to the PFR post increased the strength of the post-and-core complex. However, the strength of the PFR post did not approach that of a cast metal post and core.273

When compared with other fiber-reinforced composite post systems, the PFR posts were also found to protect the remaining tooth structure.252 These results may be attributed to the manufacturer’s recommendations of not enlarging the root canals, not removing undercuts present in the root canal, and forming a 1.5 to 2mm crown ferrule. The presence of a large volume of core material and a sufficient dentin bonding area coronally seems to greatly affect the mean load-to-failure.
value of PFR posts.\textsuperscript{232} Eskitascioglu et al.\textsuperscript{276} evaluated two post and core systems using a fracture strength test and a finite element analysis. They found that stress accumulated along the cervical region of the tooth and along the buccal bone. Minimal stress was recorded within the PFR post system. They suggested that the PFR post could be advantageous for the restoration of teeth with apical resection.

Newman et al.\textsuperscript{232} compared the effect of three fiber-reinforced composite post systems on the fracture resistance of endodontically treated teeth. They found that when PFR posts were placed in narrow canals, they performed better than GFR posts. They suggested the PFR post be formed to the shape of the canal.

The use of PFR posts to restore endodontically treated teeth appears to be a promising alternative to the stainless steel and zirconia dowel posts with respect to microleakage.\textsuperscript{277} Usumez et al.\textsuperscript{277} compared in vitro the microleakage of three esthetic, adhesively luted post systems with a conventional post system. They found that the PFR posts and the GFR posts exhibited less microleakage compared with zirconia posts.

Zirconia posts The trend toward the use of all-ceramic crowns has encouraged manufacturers to explore the development of all-ceramic posts.\textsuperscript{278–281} A metal-free post avoids discoloration of tooth structure that can occur with metal posts and produces optical properties comparable to all-ceramic crowns.\textsuperscript{282–285} One type of all-ceramic post is the zirconia post, composed of zirconium oxide ($\text{ZrO}_2$), an inert material used for a range of applications. Its high fracture toughness, high flexural strength, and excellent resistance to corrosion encouraged orthopedists to use it at articulation surfaces.\textsuperscript{286} Studies have suggested that zirconia specimens transplanted in animals were very stable after long-term aging, and there was no apparent degradation of the specimens.\textsuperscript{286,287–290}

Zirconia (tetragonal zirconium polycrystals, TZP) exhibits phase transformation. Low-temperature degradation of TZP is known to occur as a result of spontaneous phase transformation of tetragonal zirconia to monoclinic phase during ageing at $130^\circ$ to $300^\circ$C possibly within a water environment. It has been reported that this degradation leads to a decrease in strength due to the formation of microcracks accompanying the phase transformation. To inhibit this phase transformation, certain oxides (magnesium, yttrium, or calcium oxide) are added to fully or partially stabilize the tetragonal phase of zirconia at room temperature. This mechanism is known as transformation toughening.\textsuperscript{281,287,291–293}

The type of zirconia used for dental posts is composed of TZP with 3 mol% yttrium oxide ($\text{Y}_2\text{O}_3$) and is called YTZP (yttria-stabilized tetragonal polycrystalline zirconia).\textsuperscript{281,294} YTZP is composed of a dense fine-grained structure (0.5 $\mu$m average diameter) that provides the post with toughness and a smooth surface.\textsuperscript{292,294,295}

The zirconia post is extremely radiopaque, biocompatible, possesses high flexural strength and fracture toughness, and may act similar to steel.\textsuperscript{287–291,296–304} In addition, the post has a low solubility\textsuperscript{301} and is not affected by thermocycling.\textsuperscript{230} The post is available in a cylindroconical shape (Figure 21).

The zirconia post has a smooth surface configuration with no grooves, serrations, or roughness to

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{zirconia_post.png}
\caption{Available shapes and designs for zirconia posts.}
\end{figure}
enhance mechanical retention (Figure 22). As a result, the zirconia post does not bond well to composite resins and may not provide the best support for a brittle all-ceramic crown. Dietschi et al. found that these posts also have poor resin-bonding capabilities to dentin after dynamic loading and thermocycling due to the rigidity of the post. In a cyclic loading test performed in a wet environment, Mannocci et al. found that the survival rate of zirconia posts compared with fiber posts was significantly lower.

In vitro studies indicated that the smooth surface configuration of untreated zirconia posts leads to failure at the cement/post interface. The vast majority of the cement remained in the root and was not attached to the zirconia posts. Wegner and Kern evaluated the bond strength of composite resin cement to zirconia posts. They found that the long-term bond strength of the resin composite cement to zirconia posts is weak. Several studies found that acid etching and silanization of zirconia posts does not improve the strength of the resin bond to the zirconia-based material because of the lack of or no silica content in the post. However, tribiochemical silica coating was found to increase the bond strength of the composite resin to the zirconia post. Oblak et al. compared the fracture resistance of prefabricated zirconia posts after different surface treatments. They found that airborne particle-abraded posts exhibited significantly higher resistance to fracture than posts that have been ground with a diamond instrument.

The use of heat-pressed glass to form the core instead of composite resin has been suggested. This approach may improve the physical properties of the all-ceramic post and core.

When the mechanical properties of zirconia posts were evaluated, it was reported that these posts are very stiff and strong, with no plastic behavior. Pfeiffer et al. found that the zirconia post had a significantly higher yield strength compared with titanium and GFR posts.

Several studies indicated that many commonly used posts exhibit higher fracture resistance than zirconia posts. In addition, once they fracture, irretrievable posts will leave unrestorable roots. Nothdurft et al. evaluated the clinical performance of 30 zirconia posts in a short-term retrospective study. They found no signs of failure of these posts. However, these results should be analyzed with caution because of the small sample size and a short follow-up time.

Root Selection for Multirooted Teeth

PREMOLARS
When posts and cores are needed in premolars, posts are best placed in the palatal root of the maxillary premolar and the straightest root of the mandibular premolar. The buccal root could be prepared to a depth of 1 to 2 mm and to serve as an antirotational lock, if needed.

MOLARS
When posts and cores are needed in molars, posts are best placed in roots that have the greatest dentin thickness and the smallest developmental root depressions. The most appropriate roots (the primary roots) in maxillary molars are the palatal roots and in
mandibular molars are the distal roots (Figure 23). The facial roots of maxillary molars and the mesial root of mandibular molars should be avoided if at all possible. If these roots must be used in addition to the primary roots, then the post length should be short (3 to 4 mm) and a small-diameter instrument should be used (no larger than a No. 2 Peeso instrument that is 1.0 mm in diameter). When 7-mm long posts were placed in the mesial root of mandibular molars, 20 of the 75 tested teeth had only a thin layer of remaining dentin or were perforated.90

**Type of Definitive Restoration**

It is important to know the type of single crown or retainer (all-metal, all-ceramic, metal ceramic) that will be used as the definitive restoration for each endodontically treated tooth that requires a post and core. This knowledge permits the tooth to be reduced in accordance with the reduction depths and form recommended for each type of crown/retainer.

**CORONAL TOOTH PREPARATION**

Restoration of endodontically treated teeth must be a team effort between the endodontist and the dentist responsible for the coronal restoration, requiring two-way communication. If it can be co-coordinated, the first step in the fabrication of a post and core should ideally be preparation of the coronal tooth structure (Figure 24) for the type of definitive restoration that will be placed (all-metal crown, metal ceramic crown, all-ceramic crown). This procedure will help in determining the structure of the post–core fabrication. Each type of restoration requires different amounts of tooth reduction, and the form of the tooth preparation varies considerably. By preparing the coronal tooth structure first, the structural integrity of remaining dentin and enamel can be assessed. When the remaining peripheral tooth structure is very thin and would likely not possess sufficient strength to resist occlusal forces transmitted through the crown to the tooth, the thin structure is removed and replaced as part of the core. This order of procedure also establishes morphological borders that can be used to guide core fabrication so that it is confluent with the surrounding tooth structure and possesses the desired tooth preparation form.

**PULPAL CHAMBER PREPARATION**

Treatment materials present in the pulpal chamber following endodontic treatment (restorative materials
sealing the coronal access and gutta-percha) are removed by using rotary instruments (Figure 25). If a prefabricated post is cemented into a root canal and a restorative material core built around the post, morphological undercuts present in the pulpal chamber should be retained for core retention. If a custom cast post and core is fabricated, then pulpal chamber undercuts must be either blocked out with a definitive cement or a restorative material that is bonded to the tooth or the undercut eliminated by removing the tooth structure. If removing the undercut through tooth preparation would result in substantive tooth structure removal that weakens the tooth, then blocking out the undercut is the treatment of choice.

ROOT CANAL PREPARATION

The individual who completed the root canal is ideally suited to prepare the root canal, being the one that is most knowledgeable regarding root curvatures and areas where no further root preparation should be performed because it will result in areas of thin residual dentin. For this reason, it may be prudent to prepare the root canal for a post as a continuation of the endodontic treatment.

If the canal has not been prepared for a post as part of the endodontic treatment process, it is necessary to remove the filling material using either a warm endodontic hand instrument or a slow-speed rotary instrument such as a Gates Glidden drill (Dentsply International, Tulsa, OK) or a Peeso instrument (Dentsply International). If a warm hand instrument is used, it is advisable to place a rubber dam so as to prevent aspiration or swallowing of the hand instrument should it be dropped.

Successful use of rotary instruments is related to initially using a small-diameter instrument (one that removes only the filling material without dentin removal). This small-diameter instrument is used to remove small vertical increments (1 to 2 mm) of the root canal filling material. After each vertical increment is removed, a visual inspection should be made to verify that the endodontic filling material is centered in the post preparation. The incremental root canal filling removal is continued until the appropriate length is established (Figure 26). Post preparation length is determined using a periodontal probe. Remaining gutta-percha length is evaluated by comparing periodontal probing depths with landmarks on the postendodontic radiograph and by making a radiograph of the prepared post space. After the length is established, any required increases to the post diameter are performed using incrementally larger rotary instruments or hand files.

Preparation for Overdentures

“The overdenture is a complete denture supported by retained teeth and the residual alveolar ridge.”

Because the “retained teeth” are shortened, contoured,
and altered to be covered, root canal therapy is almost always required. In 1969, Lord and Teel\textsuperscript{[21]} coined the term “overdenture” and described the combined endodontic–periodontic–prosthodontic technique applied thereto. As early as 1916, however, Prothero had referred to the use of root support, stating, “Oftentimes two or three widely separated roots or teeth can be utilized for supporting a denture.”\textsuperscript{[322]} It should also be noted that much earlier, in 1789, George Washington’s first lower denture, constructed of ivory by John Greenwood, retained a mandibular left premolar.\textsuperscript{[323]}

Retaining roots in the alveolar process is based on the proven observation that so long as the root remains, the bone surrounding it remains (Figure 27). This overcomes the age-old prosthetic problem of ridge resorption. Ideally, then, retaining four teeth, two molars, and two canines, one each at the four divergent points of an arch, should ensure prosthesis balance and long “life” to a complete overdenture (Figure 28). Unfortunately, patients requiring prostheses seldom present just these ideal conditions. Decisions regarding which teeth to retain usually focus on keeping some of the healthiest teeth located in strategic positions such as canines. One situation to be warned against, however, is the diagonal cross-arch arrangements, a molar abutment on one side, for example, and a canine on the opposite side. The rocking and torquing action set up by this arrangement often leads to problems and loss of one or both abutments. The molar abutment alone is preferable to the diagonal cross-arch situation.

If the selected abutment tooth is reduced to a short rounded or bullet-shaped structure and literally “tucking” the abutments inside the denture base, the crown–root ratio of the tooth is vastly improved, especially when periodontally involved teeth have lost some alveolar support. As a shortened tooth, however, it will serve admirably as an abutment for an overdenture.

**INDICATIONS AND ADVANTAGES**

The indications for overdentures include the psychic support some patients receive from not being totally edentulous. Even more important are the preservation of the alveolar ridge and the shielding of the ridge from stress provided by firm abutment teeth. It should also be noted that occlusal vertical dimension is better preserved if ridge height is maintained. A bonus to all these advantages is the support, the stability, and retention derived from abutments. All these advantages are heightened in the young patient who must wear dentures for years to come.

Complete overdentures should be considered for virtually every patient for whom complete mouth extractions are being considered. Sometimes, certain teeth can be periodontally and endodontically treated and retained as abutments to support an overdenture. The overdenture better resists occlusal forces than the totally tissue-supported complete denture. Some attribute this resistance to the proprioceptive sensory mechanism derived from the retained roots under the overdenture. Application of the overdenture to removable partial denture support is also indicated, even if only one abutment is available.

**CONTRAINDICATIONS**

The overdenture technique is contraindicated when remaining alveolar support is so lacking that no tooth can be retained for very long. This condition often supports the use of endosseous root-form implants to support and retain a prosthesis. Overdentures are also contraindicated if the remaining natural teeth are adequate to restore the mouth with fixed partial
dentures or removable partial dentures. The overdenture technique should be no pathway to expediency.

**ABUTMENT TOOTH SELECTION**
“A healthy abutment tooth for an overdenture must have minimal mobility, a manageable sulcus depth, and an adequate band of attached gingiva.” If these prerequisites are lacking, the pocket depth can be reduced and attached gingiva developed by using appropriate periodontal procedures.

**ABUTMENT TOOTH LOCATION**
Ideal teeth to retain are those whose occlusal forces wreak greatest destruction upon the ridges. Opposite a natural dentition, the canine teeth are ideal to retain. In edentulous patients, the anterior portion of the arches is particularly susceptible to resorption, so canines and premolars are again the first choice to be saved, with incisors the second choice. It is especially important to save mandibular teeth because of difficulties encountered in retaining mandibular dentures. Even saving a single tooth, a molar in particular, may contribute greatly to long-term denture success.

**TECHNIQUE**
After the selection of the most favorable abutment teeth, the key to successful overdenture fabrication is simplicity of technique (Figure 29). If an immediate denture is to be placed, the endodontic therapy, extractions, and periodontal treatment can sometimes be done at the denture placement appointment. The crowns of these teeth are amputated 3 to 4 mm above the gingival level and the endodontic procedure completed. The coronal 5 to 6 mm of the gutta-percha restoration is removed, the preparation is undercut, and a well-condensed amalgam filling is placed to restore and help seal the canal obturation.

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**Figure 29** Preparing an overdenture abutment. **A.** The crown is amputated 3 to 4 mm above the gingival level. **B.** The endodontic procedure is started. **C and D.** An amalgam restoration is placed in the coronal 5 to 6 mm. **E.** In preparation for fitting the prosthesis, the abutments are shaped and polished.
At this time as well, the abutments should be shaped to rise 2 to 3 mm above the tissue, and be rounded or bullet-shaped with a slope back from the labial to accommodate the denture tooth to be set above it. They should then be highly polished. The abutments must not be too short or the tissue will grow over them as a “lawn grows over a sidewalk”;320 nor should they be too long, compromising the denture contour and placing greater stress on the supporting teeth (Figure 30).

The denture is relieved over the abutments and adaptation is achieved between the denture base and edentulous ridge tissues without touching the abutment teeth. It is then adapted to the abutment teeth by using a small amount of autopolymerizing acrylic resin (Figure 31). This proper relationship of denture to tissue and tooth is important for denture stability and to keep the stresses on the teeth within physiological limits.

Some overdenture abutment teeth may not need root canal therapy because they are so abraded that the pulp has receded to a level where the tooth only needs shortening, contouring, and polishing (Figure 32). This technique simplifies the treatment and reduces the cost to the patient.
If the abutment teeth are periodontally involved or are not surrounded by a good collar of attached gingiva, periodontal therapy will be required to correct these aberrations.

PROBLEMS
A number of problems have arisen with overdentures, most of them related to poor patient selection and lack of patient cooperation. The most serious problems are associated with dental caries and periodontal disease. It must be remembered that throughout their lives, candidates for complete dentures are those who have usually been neglectful of their teeth and supporting structures and have a history of extensive dental disease (Figure 33). In recommending overdentures, there is some risk. The patients’ habits must change and they must become motivated and adept at oral hygiene to retain the vestiges of their dentition. That some do not, should come as no surprise (Figure 34). The importance of good home care must be emphasized to the overdenture patient and is a critical factor in long-term success. In a longitudinal study, Ettinger and Qian evaluated the differences in people who experienced postprocedural problems with overdentures and compared them with people who had no problems for the duration of the study. They found that most of the failures could have been prevented by better oral hygiene. The most common problem was the development of periradicular problems around endodontically treated teeth because of recurrent caries causing the loss of the restoration sealing the root canal. Other challenges related to the use of endodontically treated teeth included wear of the dentin and the need for auxiliary prosthesis retention.

POSSIBLE SOLUTIONS TO THE PROBLEMS
Quite naturally the prime solution to the caries–periodontal problem is better patient cooperation in home care. Fluoride gels should regularly be placed in the “well” of the dentin base where the abutments are located to remineralize the dentin. This, of course, is only possible if the patient will use them. Home care can be evaluated at the recall visits by noting the condition of the gingiva and any mobility of the abutment teeth. If these examinations indicate that the patient is not cooperating in good home care, the dentures should be removed to allow the gingiva and bone to heal.

Figure 33 Rather typical neglect by many denture patients. A, Caries and periodontal disease forecast probable lack of future patient cooperation. B, Mirror view of lingual gingiva of two possible overdenture abutments. Because it is virtually impossible to develop attached gingiva in the lingual area, the use of these teeth as abutments is contraindicated. Courtesy of Dr. David H. Wands.

Figure 34 Two-year recall reveals advanced caries and periodontal disease of abutments. The patient did not remove the denture for days at a time. Courtesy of Dr. David H. Wands.
course, will do nothing for periodontal disease, which can only be controlled by plaque removal and by proper and equal force placed on the abutments. More frequent denture relines may also be required.

Coverage of the dentinal surfaces is recommended for those situations where wear of the contacting dentinal surfaces is noticed. Bruxism is a principal etiological factor in producing wear. Even gold castings placed over the teeth may eventually be worn through, but it takes a much longer time.328

A possible solution to inadequate denture retention or to the rotational problem centering around a single anterior abutment tooth involves the use of mechanical attachments. There are a number of attachments on the market and they include ball and socket type of attachments, o-rings and magnets, frequently retained in the root through the use of a post (Figure 35).

References


182. Bessing C. Alternatives to high noble dental casting gold alloys.


CHAPTER 41

OPERATIONS MANAGEMENT
IN ENDODONTIC PRACTICE

MARTIN D. LEVIN

The establishment of any professional practice should include the development of a vision that promotes excellence in both clinical application and performance. With the advent of new technologies such as in-office cone beam computed tomography, the emergence of molecular dentistry and medicine, new pharmacogenomics, increased dissemination of knowledge on the Internet, and improved electronic communications, we are at the threshold of a new era in patient care. Concurrently, these new technologies, improved relationships, and continual improvements in clinical and experiential performance require good management strategies and, ultimately, financial success to create and maintain an outstanding practice.

To accomplish sustainable success, we must not only have mastery of the clinical tools of our profession, but also possess the skills necessary to run a successful business.

To remain successful, this vision must include the possibility that your practice will have to undergo both planned changes to implement new procedures and the need to respond to developments over which the organization will have little or no control. In fact, it has been postulated that today “more than half of the economic value of dental care is derived from procedures that were not available just 20 years ago.”

To train practitioners and employees, upgrade technology, and improve client service continually, the practice of dentistry requires entrepreneurial training. Dr. Harold Slavkin, former director of the National Institute of Dental and Craniofacial Research (NIDCR), recognized the need for business training when he proposed increasing “the education and training of our student learners in the field of leadership and management of dental practices.” Today’s endodontist must be a clinician, infection control expert, entrepreneur, insurance and financial manager, and human resource (HR) authority.

Clinical excellence is the hallmark of every true world-class practice. What really matters is adopting an ethical and philosophical level of quality that will enable each practice to do the right thing every time. Basically, we are in the people business, and people naturally align with organizations that value integrity, compassion, quality of care, and high standards of behavior. Only by viewing your organization as a collection of interdependent systems and processes that ultimately depend on each employee to reach his or her full potential will your practice reach the desired result. As outlined by Abraham Maslow over 50 years ago, successful organizations are the ones that genuinely encourage self-actualization to ensure that people identify and pursue their own unique personal potential.

To this end, this chapter will highlight operational strategies that focus on creating a vision that will fund sustainable success by building a brand-driven culture within your organization that is supported by high-performance human systems.

Choosing How You Want to Practice

The healthcare industry is a services profession, and as such has different characteristics than companies producing physical goods. According to Leonard Berry, Distinguished Professor of Marketing at the Mays Business School at Texas A&M University, “marketing a performance [e.g., medical services] is not the same as marketing an object . . . In packaged goods the emphasis is on differentiating tangibles through imagery; in services the emphasis is tangibilizing the intangible.” To truly understand the
medical services world, Berry spent his sabbatical at the Mayo Clinic, immersed in day-to-day hospital procedures and interactions. He came away with a new appreciation for the importance of reliability as the basis of services marketing excellence. What he is saying, essentially, is that you have to do the job right the first time, every time because “who wants to travel on an airline whose pilots are usually dependable, [or] be operated on by a surgeon who usually remembers where on the body the surgery is to be done?”

As a services profession, the delivery of dental care requires both the provider and the consumer to be present at the same time. This one-on-one relationship gives rise to the potential of real-time customization, one of the most powerful tools available to healthcare providers. When you and the patient are working together to create an agreed-upon result, you can decide how much, or if any, customization will occur, and even whether that customization will occur in the front office, the back office, or both. This consultative function should be managed to create value that satisfies patient and referrer needs. From a customer-centered perspective, it means providing value that satisfies patient and referrer needs. From a consultative function should be managed to create value that satisfies patient and referrer needs. From a customer-centered perspective, it means providing what both the patient and referring doctor want, on their terms, when and how they want it.7

Organizations need to establish a strategic framework in order to reach their full potential. This framework consists of (1) a vision for the future, (2) a mission that defines what you are doing now, (3) a step-by-step strategy to clarify your individual situation and develop a program to achieve future objectives, (4) goals and action plans that guide day-to-day decision making,8 and (5) feedback to see what really works.

VISION AND MISSION STATEMENTS

A vision statement is a clearly articulated, future-oriented declaration that articulates what your organization wants to become. Vision statements range in length from a couple of words to several pages; shorter vision statements tend to be easier to recall and use. This statement should resonate with all members of the practice and help them feel proud, excited, and part of something larger than themselves. A vision should stretch the organization’s capabilities and image of itself. It should give clarity, shape, and direction to the organization’s future. Do you want to be the most technologicallyadvanced specialist in your community? Do you want to achieve a high return on your investment? Do you want to be a thought leader, a fee leader, or both? Answers to these and other questions will help you create a vision for your practice.

A mission statement is a succinct proclamation of the practice’s purpose for existence. It should include measurable criteria and address such concepts as image, customer demographics, target market, and expectations for growth and profitability. Mission statements should be broad enough to incorporate every service provided and should include the practice’s moral and ethical position, geographic and demographic domain, and the expectations as well as hopes for growth and profitability.

Once a mission statement is adopted by the organization, everyone must subscribe to its precepts or its usefulness will diminish. It is critical that you align your practice with your mission so that every interaction between employees and patients builds value. Unfortunately, the Workplace 2000 Employee Insight Survey, conducted by Tom Terez, author of “22 Keys to Creating a Meaningful Workplace,”9 found that only 23% of US workers say that their company’s mission statement has become a way of doing business.

Visions and missions are usually linked to strategies and goals that are specific, measurable, and short term. Once a vision and mission statement has been adopted and becomes part of the fabric of your practice, you can develop an implementation strategy and a list of annual goals. Finally, adding deadlines and a system of measurement will allow you to continually gauge your progress.

STRATEGIC PLANNING

What is a strategy? The word comes from the Greek word strategia, meaning “generalship.” While it is difficult to find agreement on an exact definition of strategy because it includes “thoughts, ideas, insights, experiences, goals, expertise, memories, perceptions and expectations,”10 almost everyone can agree that it is about the means to reach an end, not what those aims are or how they are established. In most successful practices, the leadership alone is responsible for assuring that the office’s policies are legitimate and ethical. Strategy, on the other hand, is the province of both leadership and management, while tactics are the responsibility of management alone. In other words, determining the goals of an enterprise is mainly a governance issue, while employment of resources is the job of management. Keep in mind that strategy is a changing perspective of what is required to obtain the ends that have been specified in policies, and is dependent on the actual results as measured by business performance. So strategy and tactics actually bridge the gap between resources and policy.

Two useful techniques to evaluate your future practice’s potential for success are the SWOT (Strengths, Weaknesses, Opportunities, and Threats) and PEST
(Political, Economic, Social, and Technological) analyses. A SWOT analysis measures a business proposition or idea. Long-range strategic planners often use SWOT analysis to assess core issues and develop a plan based on current perceptions (Table 1). Practices can also benefit by completing a SWOT analysis to evaluate a competitor.

A PEST analysis helps to measure the external macro-environment that affects all businesses. The most useful analysis for a dental practice will be the social and technological analysis portion. The social section is where patients’ and referrers’ demographics, class structure, education, culture, and attitudes about healthcare are considered. Technological analysis looks at recent technological developments, their impact on the value-chain structure, cost, and efficiency. For example, should you consider purchasing or leasing a cone beam computed tomography scanner, panoramic device, or refer patients needing advanced evaluation to a center with these capabilities? PEST analysis allows for proactive marketing and business development assessment.

**SETTING GOALS**

Goals are plain language statements that describe priorities or actions to be accomplished. Practices should have a number of goals, each describing a desired result toward which your efforts should be directed. Goals set priorities for management and staff and establish measurement parameters for evaluating success. Goals serve to keep an organization focused on success and away from activities that tend to distract and drain resources. If the goals are accomplished, then the business should be a success.

Practice goals are generally derived from mission statements and describe how the mission will be accomplished, while mission statements describe exactly what needs to be accomplished. A goal should be simple, clearly written, state the conditions that will exist if the goal is accomplished, and set action-oriented tasks that you want to accomplish in 1 to 3 years. Some business goals will have a 1-year time frame, while others may have longer or shorter time frame. It is not unusual for a practice to have a mix of business goals starting and ending at different times. Most importantly, a goal needs to be achievable and challenge the people responsible for its accomplishment.

As more employees understand and commit to your vision for the practice, it is the job of leadership to continually reaffirm it through every available channel of communication, such as staff meetings, or when conversing with co-therapists, and so on. According to Lionel Urwick’s classic *Harvard Business Review* article, 1956, “There is nothing which rots morale more quickly and more completely than...the feeling that those in authority do not know their own minds.” Once the plan is created, be ready to change it. Strategic plans are dynamic, living documents that are not a once-a-year project, but can be modified repeatedly as it needs warrant. Strategic planning is one of the key activities that forces organizations to focus on the right priorities to foster growth. In the end, all strategic planning models are goal-based and rely on clearly defined, understood, and communicated action steps. A strategy is not useful, however, if it is not realized. A Fortune Magazine study has shown that 7 out of 10 CEOs fail because of poor execution, not because of bad strategy.12

**PRACTICE MODELS**

Unlike the practice of medicine, which is becoming increasingly complex and business-like, Marjorie Jeffcoat,13 the Morton Amsterdam Dean at the School of Dental Medicine, University of Pennsylvania, says that “dentistry has remained a profession dominated by small, independent practices.” In fact, Kathleen Roth, president of the American Dental Association (ADA), in a 2007 address to the Small Business Committee of the U.S. Congress, reported that over 90% of practicing dentists are in the private sector and 85% of those practitioners operate independent solo practices.14 But the need to investigate organizational alternatives is becoming more urgent with the expectation that there will be a sea change in the way health care is organized and funded in the future. While dentists may continue to practice independently, other dental practice models will show strong growth and evolve as business entities.
Armstrong et al.\textsuperscript{15} have postulated that some practices adhere to the “service factory model,” where low cost and standardization predominates, delivering consistent but standardized service. Conversely, other practices act as “service theaters,” or niche practices, where a select clientele undergo premium-priced procedures that are individualized and scripted for maximum effect. Patients choose this type of practice if price is no object. They want a high-tech approach, presented with personal attention in an office that rivals the ambiance of a fine hotel. Employees are not just hired here; they are trained to serve as members of a team that values a high-touch, patient-centered experience.

Other attempts to categorize practice models have been proposed by the Dental Trade Alliance (DTA). Jeffery Lavers,\textsuperscript{16} Marketing Director of 3M ESPE, says that continual change in the dental marketplace is certain and will be influenced by demographics, technology, disease patterns, patient behavior, and service choices and dental workforce. Providers of dental care, for example, will be reduced from their current level of 130,000 full-time equivalent practicing U.S. dentists by more women providers practicing fewer hours and lower numbers of dental school graduates than in the past. These factors and an associated increase in the U.S. population will continue to decrease the dentist/population ratio.

The DTA has proposed the following emerging practice models, which it predicts will provide over 60% of all dental services by 2010 (reproduced by permission of the DTA):

**Ready Access Model**—High-process standardization, convenience-oriented, highly flexible operating systems, focused on a dynamic “retail” service experience

**Tech Station Model**—High level of technical resources, procedural leading edge, “gee-whiz” experience backed by relatively high-touch patient communication

**Small Group Model**—Well-integrated staff with broad range of scope, seamless teamwork of staff geared to provide service efficiency and throughput

**Cosmetic Center Model**—A variation on the conventional practice with heavy emphasis on elective care in personal aesthetics and restorative services

**Super Norm Model**—Emphasis on high-touch, service-intensive patient experience, customer intimacy, and high-margin work with demanding patients

Armstrong’s service theater approach is similar to the “super-norm model” proposed by the DTA’s description of emerging practice models, with an emphasis on a customer-centered approach that treats demanding patients and produces high-margin work. Practice models will continue to evolve, and some practices will incorporate elements of several business forms. One practice model may use technology while also providing cosmetic procedures based on personal aesthetics and high-end customer service. What does all of this have to do with your endodontic practice? Simply put, running a successful practice requires a powerful vision of where you want to go.

Starting a new practice, associating with an established endodontic practice, or choosing a hybrid format is the first of many decisions that every endodontist will have to make when beginning his or her career. What follows is a short primer on the risks and benefits of three employment options.

**NEW PRACTICE**

What are the benefits of starting your own practice? You will have complete autonomy in setting practice policies and making decisions. Every decision, that is, the selection of particular equipment and designing treatment protocols, as well as the selection of employees, will be yours to make. When it is your business, you dictate the way things are done. The scheduling of employee and your own vacations is at your discretion. Then there is personal fulfillment. Owning and running your own business can be more satisfying than working for someone else, and many practitioners enjoy the respect they earn from their peers for having the courage to go out on their own. When you own your own practice, you may have to forgo a regular paycheck, but the upside earnings potential may be greater than any other alternative. If these aspects have strong appeal, then starting your own practice should be considered.

There are formidable risks to starting your own practice, and a careful analysis is critical. As a sole practitioner, you must spend the time to research all decisions yourself or engage advisors to assist you in this process. Solo practice will require an emergency coverage arrangement with another practitioner when you are out of town. You will have no immediate peer consultation to explore the treatment of difficult cases. And you will face a greater risk of losing your investment. Although relatively rare, some practitioners just cannot earn sufficient income to remain
profitable. This may occur as a result of choosing a poor location, competing unsuccessfully with established neighboring practices, or assuming too much debt. Finally, opening your own business can come at a high personal cost. It will take a lot of energy and personal sacrifice to get going, likely necessitating working at night and on weekends, infringing on personal time.

ASSOCIATE-EMPLOYEE OR ASSOCIATE-INDEPENDENT CONTRACTOR

For a recent graduate with little or no prior practice experience, the benefits afforded by having a transitional period with an established practice can be priceless. Serving as an associate-employee allows the new practitioner to assume the reputation of the other member(s) of the practice, and by inference, more quickly establish a good professional reputation of his or her own. Other benefits include practice ownership opportunities, no initial financial investment, immediate patient flow, peer clinical consultation, shared emergency coverage, and the freedom to move easily to another locale if a change is desired.

Risks of the associate-employee and associate-independent contractor path include the lack of total control over the practice, loss of individuality, and the legal constraint of practicing with a restrictive covenant. A restrictive covenant is a contractual agreement usually between an associate and his or her employer that prevents the associate from practicing in a certain geographic area for a specified time period after termination of employment. These agreements are used by employers to protect their investment in start-up costs associated with bringing on an associate and their referral network from competition. Most contracts will include a restrictive covenant, also known as a non-compete agreement. Generally, courts have held that restrictive covenants are enforceable, but not in all states or under all conditions, so get good legal advice.

Associate-independent contractors are independent practitioners who provide services to a dental practice on a contractual basis. This form of practice must be carefully structured to remain in compliance with Internal Revenue Service (IRS) guidelines. Under current IRS rules, the practice owner cannot control both the means of work and the results of the independent contractor’s efforts. No benefits, retirement plans, or employment taxes are paid by the practice for the associate-independent contractor. Additionally, the practice owner cannot furnish supplies, equipment and instruments, impose safety precautions, plan work to be done, control office hours, or assume liability stemming from the independent contractor’s performance. The associate-independent contractor relationship must be properly constructed to avoid incurring significant taxes, interest charges, and penalties. This is the province of an attorney with experience in such transactions.

HYBRID

A hybrid form of employment may include any combination of the following part-time schemes: (1) serving as an associate-employee or associate-independent contractor in an established endodontic practice, (2) starting your own practice, and (3) serving as an independent contractor in one or more general dentists offices. The latter will not likely result in a stable long-term practice situation, and should be viewed as a temporary solution, at best. The value of this arrangement is that it can serve as an interim step that can financially sustain the new endodontist until he or she builds a referral base.

Winning Management Practices

Forming and operating an endodontic practice is a complex and nuanced undertaking. The notion that we are simply a profession and not also a business seeking financial success is to miss the opportunity to generate fair compensation for your knowledge and professional skills. Generating a healthy revenue stream is the only way to ensure that you can continue to provide the most advanced care available. In fact, Joe Blaes, editor of Dental Economics, states that “it is impossible for you to stay in practice without a reasonable profit.” 17 How do you learn the basics of practice profitability? By studying other businesses to gain insights about operations management and best practices.

What really works in the business world? In the landmark Evergreen Project, 50 leading academics, led by William Joyce, Professor of Strategy and Organizational Theory at Dartmouth College’s Tuck School of Business, and Nitin Nohria, the Richard P. Chapman Professor of Business Administration at the Harvard Business School, 18 looked at 40 narrowly defined industries with $100 million to $6 billion in gross revenue and determined that winning companies adopted four primary management practices and two of four secondary management practices. Adapting this scheme to endodontic practice, the following sections summarize the study’s findings:
PRIMARY MANAGEMENT PRACTICES

1. Strategy: Develop a step-wise plan to clarify your individual situation and develop a program to achieve future goals:
   a. A clear value proposition: What patients and referrers want most are results and process quality. That the endodontic treatment works and the patient can maintain their dentition and the treatment meets or exceeds the specifications of the referring doctor is only the “results” part of the equation. “Process quality” measures how the patient was treated. This is the experiential piece, and endodontic treatment is usually defined by patients in these terms. At the end of the day, when patients ask the question “How was I treated?,” they are actually assessing process quality. Remember, there is no reasonable way for patients to easily understand the five points of the technical side of treatment.
   b. “Outside-In”: To put this concept in perspective for our profession, it means understanding what your patients and referring doctors want and creating systems to satisfy those needs, from their perspective. Finding out exactly what patients and referrers deeply value and how to deliver it with passion is the holy grail of practice excellence.
   c. Continually measure and refine: Practice metrics can be an important indicator of your success. Understanding the referral process, measuring new patient referrals, and tracking “fading referrals” are examples of ways to measure the success of your efforts (Sidebar 1).

MEASURING CUSTOMER DEFECTIONS

In today’s competitive marketplace, success in a referral-based business like endodontics is all about building relationships. According to Frederick Reichheld, a business consultant and author of The Loyalty Effect, a business invests in customers, and premature customer (e.g., referring doctor) defections will ultimately result in diminished profitability.

Reducing defections (also referred to as “fading referrals”) begins with measuring the rate of defection. According to Reichheld, in another article in the Harvard Business Review, “customer defection is one of the most illuminating metrics in business.” Some defections are normal in any business and in rare cases they can even be welcomed. A percentage of referring doctors will never be loyal and can even diminish morale and increase stress if they continue to send patients. But, such welcomed defections are few and far between. In most instances, it is important to preserve and encourage continued referrals. So, what action should you take if a referral begins to fade? The best approach is to contact the individual who has stopped making referrals and find out why. Always avoid getting defensive, practice active listening, and no matter what you hear, thank them for their time and candor. You may not get these referrers back in the fold, but you may learn how to keep others from defecting in the future.

Once you loose a referrer, replacing him or her will not be easy nor inexpensive. In fact, Reichheld’s survey of 100 companies in 24 industries found that longer customer retention led to increased profits. No surprise here. Many companies make the mistake of not even keeping track of customer defections because they are unaware of the cost to replace them. And many business owners find that customer defections are hard to track, especially when referrals are based on business cycles and sometimes involve only partial defections. Measuring defections can be unpleasant and remedial action is often difficult to accomplish. Even so, it is important to quantify such defections and set goals to improve those relationships.

Measuring referrals is a necessary part of operating a referral-based practice. Look for practice management software that analyzes referral trends within a given time period. It should take just a few mouse clicks to get the information. Some industries report that reducing defections “by as little as five points... can double profits,” and monitoring the “fading referral” to measure declining business will yield valuable insights that need to be addressed immediately.

The most profitable companies champion customers, recognizing that the longer a company keeps its customers, the more successful it will be. Loyal customers result in more profits, because loyal customers buy more, take less of a company’s resources and are willing to pay a price premium. Why? Because they do not want to start with new people either. Best of all, loyal referrers and patients are more likely to refer new patients.
d. Keep focused: Understand your core business and focus on the convergence of what you do best and most profitably with what your patients really want. Consider a focusing matrix showing the relationship between what you do best and what your patient’s value most (Table 2). When the two converge, you have a winner!

2. Execution: Deliver products and services that consistently meet patient expectations. Every business tries to set their customer’s expectations. This research project has demonstrated that consistently satisfying customer expectations is far more important than exceeding expectations in one or more areas and falling below the grade in another. The customer will judge and remember the worst performing parameter or interaction, and his or her negative experience will overshadow any exceptional service provided. Another way to improve is to eliminate waste and increase productivity by constantly evaluating operations and making changes that improve the bottom line.

3. Culture: Inspire to do your best. Every office employee looks to the doctor(s) and office administrators for leadership. We must continually refine and measure our care and motivate the members of our office team to strive for excellence. Rewarding achievement with acknowledgement and remuneration based on performance will create a fulfilling workplace.

4. Structure: Simplify. Placing the best employee(s) close to the customer is another way top businesses achieve outstanding results. While most businesses promote the highest achievers to the next level in a vertically structured organization, this action usually takes the best and brightest and moves them away from the customers who interact with the company. So consider this action carefully when reorganizing your staff. Keeping the vertical structure will simplify administration and will allow the staff with the best people skills to stay closest to those they serve.

### SECONDARY MANAGEMENT PRACTICES

The Evergreen study also found a correlation between any two of the following four secondary attributes:

1. Talent: The value of developing and keeping great employees cannot be underestimated; most winning companies reward exemplary employees to keep them motivated. These rewards can take many forms, among them salary, benefits, vacation, and probably most importantly a safe and inspiring working environment that drives personal achievement.

2. Innovation: Advanced services and technologies are critical to your success. Working with sophisticated practice management software, advanced communications between the office and co-therapists, and treatment technologies such as microscopes and digital radiographic are increasingly important and expected.

3. Leadership: Trust and confidence in top leadership is one of the single most reliable predictors of employee satisfaction. Leaders help employees understand the organization’s overall business strategy and how they can contribute to achieving key business objectives. Sharing information and communicating about performance in a small office environment by non-professional HR managers/doctors can be challenging. To improve overall performance, rewarding individual employees and managers for leadership and creativity is a must.

4. Mergers and partnerships: Partnering with another practice to maximize the value of diverse talents is often overlooked in cottage industries and small businesses. Strategic alliances and mergers of individual practices to provide better coverage and economies of scale can produce benefits. This can take the form of an alliance between several endodontic practices or the combining of an endodontic practice with a periodontal practice, and so on. Establishing a solo group where two or more endodontists practice in the same facility with shared common areas and administration but separate practice entities is another possibility to economize and protect against the consequences of disability or death.

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The Focusing Matrix demonstrates the convergence of what you do best and what your patients and referring doctors value most. For example, take one-visit endodontic procedures. These are valued by your patients and referrers and are more efficient for your office to perform. Put them in the “Go” category. If a procedure falls in the “Stop” category, consider a change.
How to Get Started

Opening a new office for the practice of endodontics will require many months of planning. The project should begin with identifying your objectives. Do you want to establish a boutique or niche practice or a more traditional practice? Will you accept insurance assignment or participate with a preferred provider network or health maintenance organization? To succeed, you will need to make sure your practice will be appropriate to the needs and expectations of your community.

Begin by creating a business plan, develop a timeline, and establish an office location that will accommodate the unique requirements of an endodontic practice. Because endodontic offices require special planning, the time needed for construction and installation will far exceed the time and expense required for a typical non-healthcare facility. Ranking variables like location, parking, home-office travel times, amenities, and proximity to other medical and dental practitioners are necessary parts of the decision-making process. To get this right, you will need the services of an attorney, accountant, banker, commercial real estate broker, architect, interior designer, dental equipment supplier(s), and computer and telephone system engineers.

FIRST THINGS FIRST: CREATING A BUSINESS PLAN

The two essential elements of a good business plan are a winning vision and a clear path to profitability. To borrow money, carefully design the plan to “sell” your vision to a skeptical bank loan officer. The business plan should include the following:

1. A persuasive introduction to describe your planned practice, including features and benefits, and a request for funds.
2. A statement of the purpose.
3. A detailed description of how an endodontic practice works, office location overview, whether you will have employees, and who will provide your equipment and supplies.
4. An analysis of your market demographics (who are your patients?).
5. An evaluation of your main competitors.
6. A description of your brand strategy and how you will use marketing to drive your brand to top-of-mind-status (see “Branding: Enabling Your Practice Success”).
7. A resume setting forth your educational and professional accomplishments.
8. Detailed financial information, including your best estimates of start-up costs, revenues and expenses, and your ability to make a profit.

Help in designing a business plan is available from the U.S. Small Business Administration (SBA) and online software guides like Business Plan Pro (Palo Alto Software, Eugene, OR). Focus on creating a polished plan that can be presented to several bankers and their loan boards for consideration. The better it looks, the more likely you will get a favorable loan offer. If you are self-financing, concentrate on financial projections, because the cost of services, sales revenue, and profit will all figure prominently in how much you will have to invest. Remember that starting a new professional business will require money to market the practice. Very few offices today, especially in crowded urban markets, can just hang out a shingle and expect to be busy. Good planning requires making educated guesses about income and spending, based on the following projections:

1. A break-even analysis to determine if you will make money:
   a. Projected collections
   b. Fixed and variable costs (estimate)
   c. Gross profit
   d. Break-even revenue
2. A start-up cost estimate to evaluate the amount of money needed just to open the door on the first day of practice.
3. A profit-and-loss analysis to refine the month-to-month projection of profits for the first year of practice.
4. A cash flow projection to ensure that even if your business is profitable, there is enough money on hand to operate from month to month.

No business plan would be complete without consideration of what business structure the practice will take. Keep in mind that this decision will affect your personal liability as well as the amount of tax you and your organization will pay. Whether you choose a “C” or “S” corporation, a limited liability company (LLC), limited liability partnership (LLP), general partnership, or sole proprietorship, your attorney and accountant will need to provide advice.

CHOOSING AN OFFICE LOCATION

Choosing where to practice is one of the most important decisions a new practitioner will make. Family considerations, personal preferences, weather, career opportunities for your spouse, and lifestyle issues are
among some of the considerations that should govern your decision. Establishing a successful endodontic practice will require a location that will provide enough new patients to support the practice’s expenses and result in the best opportunity for you to utilize your skills. Because the number of dentists in postdoctoral endodontic programs continues to increase faster than any other dental specialty,19 practice location will prove to be a key predictor of success. Studies by Wright,20 and Solomon and Glickman,21 using sophisticated statistical analysis, clearly establish the relationship between the location of general dentists and the location of endodontic offices. Because endodontic practice is referral-based, the proximity of a referral network, followed by adequate population and other criteria such as socio-economic characteristics, are all variables that will affect the economics of your practice. The economic potential of your proposed office location should be appraised to determine its professional desirability. People living in similar neighborhoods generally exhibit similar lifestyle and spending profiles. One of the easiest ways to learn about your clientele is to understand their geodemographical classifications. These data, available from vendors like Business Information Solutions (ESRI BIS, an internationally recognized provider of information services), will allow analysis of clinic site locations by creating a visual depiction of data which is spatially referenced to the earth, also known as geographic information systems (GIS) mapping. GIS-generated information will greatly improve your business planning and allow you to base location and growth decisions on the best available information. A new type of classification introduced by ESRI BIS, called the “Community Tapestry” segmentation system, provides an accurate, detailed description of America’s neighborhoods. U.S. residential areas are divided into 65 segments based on demographic variables such as age, income, home value, occupation, household type, education, and other consumer behavior characteristics. ESRI BIS offers market surveys that provide a detailed look at data within various radii around a given geographical address. This is called a “Market Profile Report” and is based on the updated U.S. Census, including 5-year projections. Reports can also be ordered with specific filters, such as a plot of all general and specialty practices in the zones of interest. You can find them on the Web at http://www.esribis.com. Also, ESRI BIS offers a free Web-based lookup of demographic data based on ZIP codes, but ZIP codes will not provide adequate specificity for making a final decision. 

Further analysis can be performed by purchasing a list from your state dental society in Excel format, and then using a program such as Microsoft MapPoint to plot the data. Of course, there is no guarantee of success with any particular location, but a poor choice may lead to economic hardship. It is critical that you create a comprehensive plan to assure that your proposed site is architecturally and financially sound. Plan on specifying about 400 to 500 square feet per operatory in your new office.22

According to Gregory L. Morgan,23 Managing Director of Sperry Van Ness – Morgan Realty Advisors, specify your geographic parameters, space requirements, parking availability, modes of access, and street exposure if applicable. Then engage an experienced commercial real estate leasing professional to canvas your prospective area and match your requirements with properties using real estate databases, brokerage relationships, publications, and the Internet. Comparing the economics and qualitative differences between properties and market information is where a commercial real estate leasing professional will provide essential guidance. Hopefully, you will have several options to review, creating a competitive atmosphere where multiple landlords are competing for your business. As you will learn early on, the effective rent can be based on one of several formulas, and extending these costs over many years can add up to a significant difference. Even if you are especially focused on one of these locations, it is important to go through the exercise of requesting proposals from several property owners and managers. Some landlords will offer concessions in areas where others will not, helping you to identify the most important considerations for your business: property location, economics, and functionality. Analyzing the proposals will then help you request aggressive but fair economic concessions from the finalists based on what other competing landlords have offered.

The next step is to decide on the number of operators and what supporting facilities will be required. Engage an architect or dental office designer to draw basic floor plans and confirm that adequate plumbing and electrical infrastructure needs are met. Now, with several lease proposals in hand, you should meet with a real estate attorney for further analysis. According to leasing attorney Charles J. Levin,24 some of the attributes of a successful commercial lease are summarized as follows: (1) lease terms and conditions are expressed in a complete written lease with no oral agreements and understandings; (2) all contingencies are considered and resolved; (3) lease terms and conditions are aligned with your needs; (4) the leased premises suits your needs; (5) you have protected yourself from operating expense charges that are not customary and
you understand what to expect with those that are passed through; (6) there are no defects like possible noise, odor, vibration, or other similar problems; (7) you have warranties protecting you from issues such as zoning, water quality, mold, asbestos, Americans with Disability Act (AaDA), and so on; (8) you have thoroughly reviewed the build-out letter with your architect and contractor and included all necessary details in the lease; (9) you have expressly excluded certain types of objectionable tenants from being in the building or on your floor (e.g., music school, barbeque restaurant, and social security office); (10) you have flexibility to renew, expand, and terminate; (11) you have option to purchase, if appropriate; (12) other tenants have no major complaints; (13) you have looked into the future and considered all of the possibilities with respect to issues such as fire and casualty, condemnation, changes in governmental requirements, assignment and subletting, and the many other issues that can arise; and (14) you, your commercial real estate leasing professional, attorney, and architect have all reviewed your office selection. Lastly, create a ticker file in your office management software as a reminder of notification dates memorialized in your lease.

Levin further emphasizes the importance of you being engaged in all aspects of the negotiations and that you understand the significance of each and every provision of the lease as it is being negotiated. It is a mistake to hand the lease to your attorney for negotiation and expect that your interests are being protected without your involvement. There are many aspects of the lease that combine both business and legal issues that will have a profound effect upon the success of the practice. The selection of an experienced commercial real estate leasing professional and real estate attorney cannot be overemphasized because of the complex and nuanced nature of leasing space and the long-term and potentially devastating implications of getting it wrong.

Once the lease is executed, the next step is contacting the telephone company to obtain a telephone number and secure a listing in the local phone directory. Many telephone providers will allow you to select a unique telephone number without charge or for a small fee. Generally, it is only necessary to secure one number, which will serve as your main trunk line. Additional numbers can be secured at a later time for use with multi-line phone systems, to avoid paying for reserving hidden numbers prior to the opening of the office. Today, most offices will have a choice between several trunk line providers and systems, such as copper wire or fiber optic. Use of Internet phone services over fiber-optic connections, such as Voice over IP, is becoming more popular, and packaged with Internet connectivity and television services, may prove a viable alternative to traditional service.

After securing a telephone number and phone book listing, order the practice management software and a computer workstation which will become the front desk system. Once setup, this workstation can be located off-site to configure your practice management software and allow training of new employees. Every endodontic practice, including a de novo practice, must have practice management software to manage appointments, prescriptions, reports, and other communications with referrers, not to mention the financial aspects of treatment and insurance.

CREATING A WINNING OFFICE DESIGN
Although building a new office from an empty shell is a daunting challenge, it provides the opportunity to set up the office to your specifications, within budget and space constrains. A key element to insuring success is the early involvement of your design team—and the design team starts with your architect or dental design firm. Try to choose an architect who is familiar with the design of medical facilities, the AaDA (Americans with Disabilities Act) standards, hygiene requirements, and your local building codes. By helping you define the building project, architects can provide meaningful guidance for the contractor and other construction professionals. They can conduct site studies, help secure planning and zoning approvals, perform a variety of other pre-design tasks. Evaluate for handicapped patients, transportation, parking, and general convenience. When experienced architects are involved at the earliest planning stage, they gain opportunities to understand your business, develop creative solutions, and propose ways to reduce costs. The long-term result is a facility that adds to the productivity and image of the practice. Specialty architects who design just dental or healthcare facilities are also an excellent option, and the more endodontic offices they have designed, the better probability that all details will be considered.

The American Institute of Architects provides good resources on their Web site and lists numerous standard agreement forms that can be tailored to the types of services that are required.

Steven Covey’s maxim “begin with the end in mind.” plays a large part in creating your desired outcome. What do you want your office to look like? How will patients and referring doctors be best served? Of course, ownership of your space in either a condominium or a stand-alone building that you
are purchasing or building will require special considerations.

After the plans are approved by the building owner, your architect and/or dental designer will be responsible for meeting with you and any interested contractors to explain the scope of the project and solicit a quote for construction. The following architectural drawings and specifications will need to be available: (1) site plan; (2) demolition plan, if applicable; (3) reflected ceiling plan; (4) mechanical plan, for example, smoke/fire detectors and fire annunciators, sprinkler system, heating, and cooling; (5) electrical plan, for example, power, telephone, and computer installation; (6) plumbing plan; (7) millwork; and (8) finish schedule, for example, flooring, wall coverings, and paint. The contractor will generally be responsible for getting approval from local building officials to begin construction.

Designing the office for new and even future technologies will require some coordination between the various planners of your space. The wires and cables must be installed and integrated for the practice management system, digital radiography, entertainment, power, fire and smoke annunciators, security systems, and climatic systems.

Design Aesthetics

According to Schmitt and Simonson,28 “aesthetics is one of the major satisfiers in consumers’ experiential worlds.” They state that intangibles like experiences become key selling points when services are perceived as the same across an industry.

How can Starbucks charge over $4 for a cup of coffee? It is because they provide experiences that customers can see, hear, touch, and feel—experiences that add value and allow for premium pricing. In the same way, your practice will become identified with certain traits that create a practice image, requiring “a careful mapping of a strategic vision to create sensory stimuli and communications that evoke that vision – that instantiate the identity”.29 It is important to establish a style that is consistent throughout everything your practice does, from your Web site, to your brochure, to the design of the office interior. Bloch,30 in his research to conceptualize consumer reactions to a product’s design, says there are three basic consumer responses, namely, “cognitive, affective and behavioral”. He goes on to state that product form—or in this case office aesthetics—influences behavioral responses through cognitive and affective responses and are based on individual tastes and preferences.

Research in the organizational sciences has shown a direct relationship between office design and impression management. The physical environment will convey social messages to your patients. Consider designing with positive visual impact, such as added accent lighting, dry-wall soffits in key areas, upgraded ceilings, an enhanced level of detail and color balance, pleasant artwork and furnishings, and fabrics to further establish your desired image. Keep in mind that some businesses, such as Starbucks, have left the traditional marketing to their competitors, differentiating themselves through the inviting “look” of their hip aesthetic that evokes a satisfying experience.30 Some of the “don’ts” when it comes to office design are creating physiological barriers, that is, sliding glass enclosures between patients and the patient coordinator, showcasing your hobbies; unclean, inexpensive, or misarranged furniture; and off-putting signs in the reception area [a big no-no, with the exception of a Health Insurance Portability and Accountability Act (HIPAA) notice, if applicable]. Signs that tell patients about office policies, in general, are unwelcome reminders of what your office personnel should have advised either verbally, or in the office’s literature or Web site in the first place.

Branding: Enabling Your Practice Success

Dental practice begins as a journey after dental school with little or no training in the business aspects of practice. Unfortunately, talent and education alone are not enough to ensure success in our increasingly competitive healthcare marketplace. Getting and keeping patients in our endodontic practices will undoubtedly become more challenging, especially in mature urban settings. In order to develop long-term, directed growth, we must learn to manage our practice building efforts through trial and error, intuition, reading, continuing education, and use of management consultancies.

Before we address the ins and outs of practice operations, we should first explore the case for concern, the meaning of branding, and ultimately how to build a brand-driven culture within your organization. At the end of the day, building you brand in a way that energizes all referrers, patients, vendors, and employees must become the mantra of your operational strategy.

THE CASE FOR INCREASED CONCERN

In the United States, we are facing many new challenges in private endodontic practice. Endodontics is one of the smaller clinical specialties in dentistry, with about
4,000 practicing clinicians in 2007, and a population to endodontist ratio of about 75,000 individuals per endodontist. However, with our population projected at 340 million in 2035, and with endodontists graduating and leaving practice at approximately the same rate as today, we are projected to have approximately 6,580 active clinicians or a population to endodontist ratio of 54,270 individuals per endodontist. At current graduation rates, the number of dentists completing endodontic residency programs has been increasing faster than the number of general practitioners, and as a consequence, the practitioner to endodontist ratio has also been declining. The vast majority of endodontists practice in the Northeast and West Coast areas, and if misdistribution trends continue, the number of over-served areas will continue to increase with resultant case-load challenges. Other factors, such as the higher relative failure rates in restorative materials like resins, general dentist busyness, and increased productivity among all practitioners will continue to be some of the issues affecting the profession. A report by the DTA concluded that up to 40% of all practices are not reaching their full production. By the year 2010, it has been postulated that less than 40% of all dental care will be provided by non-owner doctors rather that more traditional practice models. The competitive landscape will continue to change, according to Eric Solomon, Professor of Public Health Sciences at the Baylor College of Dentistry, in his Dental Economics article “The Future of Dentistry.” He predicts that the number of specialists in dentistry will increase from the current level of 20% to 27% by the year 2020,” leading to an increasingly competitive marketplace for the new specialist. The days of opening a new office in a major metropolitan area and instantly generating a sustainable financial model are becoming increasingly rare.

Increasing competition, demographic shifts, market saturation, bunching of endodontic practices in already crowded urban centers, insurance company control, and an insidious lack of customer loyalty will always challenge endodontic practices in the most desirable markets. Central to meeting these challenges is creating a brand identity that consistently conveys our special skills to referring doctors and patients. What follows is a summary of branding basics, with an emphasis on the connection between best business practices and the dental profession.

UNDERSTANDING YOUR BRAND

What is a brand? A brand is simply a promise—the expectations that exist in each customer’s mind about a product or service. According to John Hagel, a business strategy consultant, in the past, a brand used to say, “If you buy this product or buy from my company, you can rely on me because of the attributes attached to the brand.” He goes on to state that we are seeing “a new kind of branding emerge, a much more customer-centric branding, where the promise is, ‘I know you as an individual customer better than anyone else, and you can trust me to assemble the right products or services to meet your individual needs.’” Brands are imbedded in our minds and used in our daily lives, like “FedEx that photo to San Francisco.” Your brand is your personality; brands are the reason that companies exist, and they are based on multiple experiences over time. These experiences, from the patient intake process through treatment and post-treatment interactions, need to be delivered with consistency and be perceived as unequaled relative to the competition. In short, your patient’s and referrer’s experiences need to result in deep, trust-based relationships which generate loyalty. Your brand should reflect a high level of education, proficiency, and confidence that you are offering the best care.

While brands speak to the mind, brand identity or brandmark is the sensory expression of a brand. You can touch it, hear it, feel it, and it increases the customer’s consciousness and builds loyalty. Your brandmark can include a name, design, or symbol that visually represents the value of your practice beyond its functional purpose. The velocity of life in the future will inevitably demand that brands leverage the power of symbols. Whether it is a photograph, mark, graphic, or typographical image, which can be as simple as the practice name written in an artful font, symbols can trigger recall and stimulate emotion. A brand identity helps to manage perceptions of your practice and differentiates it from other practices.

Offices must deliver their services to create value that relies on understanding results and process quality from the referrer’s and patient’s perspective. When it comes to understanding your clients, according to Marty Neumeier, a branding consultant, “Brand is not what you say it is. It is what they say it is.” Although branding is a simple concept, it is not that easy to accomplish. It takes a long-term commitment and hard work.

In the early 1990s, brands were a series of marketing tactics like the advertising icons made famous by Nike, Alka Seltzer, and even KFC. Brands now have strategic importance, brands result in deep, trust-based relationships which in turn garners customer’s loyalty. Products and services need to be delivered with consistantly high level of quality and value, perceived to be unparalleled relative to the competition.
Adopting this brand-driven approach, “where making the brand the central focus of the organization clarifies what is ‘on-brand and what is off-brand’”, then the entire organization needs to adopt this brand-driven approach to guide critical business decisions as well as determine appropriate staff behaviors. Building a brand-based culture is simply not a quick fix program. It requires a solid dedication to the organization’s brand vision and an understanding that branding cannot be overemphasized an overall strategy.

As we learned in the beginning of this section, a brand is a promise that defines a patient’s value proposition that both their treatment and their experience will be as expected or better than expected. “It has meaning, prestige, and presence, and it helps confirm what is expected.” The treatment performed must be unrivaled and the patient and referrer experience must be unequalled. According to Prophets 2002 Best Practices Study, there are three main goals of any branding strategy: (1) increasing customer loyalty, (2) differentiating your organization from the competition, and (3) establishing market leadership. Let us look at each of these goals and how they affect practice success.

1. Increasing customer loyalty: A classic study by Xerox in the 1990s (Figure 1) looked at satisfaction and found that highly satisfied customers were six times more likely to repurchase a Xerox product than a merely satisfied customer. This means that every highly satisfied patient will demonstrate repeat behavior and require much less effort on your part to maintain their loyalty than patients who are just along for the ride. Even more important, a patient who repeats their behavior is much more likely to continue repeating it, becoming more profitable as time goes on. For example, it takes the average credit card company 3 to 4 years of marketing effort to attract a new customer, or 7 to 10 times the cost of merely maintaining an existing customer. An increase in customer loyalty of just 2% will equal the equivalent of a 10% cost reduction program, and an increase of 5% in loyal customers can deliver 95% greater profitability over the lifetime of that customer. Even more striking is that 50% of customers will try a new product or service from a preferred brand because of the implied endorsement, credibility, and trust. According to Robinette et al. of Hallmark Cards, Inc, “increased customer loyalty is the single most important driver of long-term profitability.” If we look at the lifetime value (LTV) of a top-tier referring doctor whose career spans 35 years, revenue generated will easily exceed $1.5 million. While calculating LTV is complex because of varying costs to acquire and maintain each customer, there is no doubt that looking at the “customer back” will allow formulation of strategies for each customer segment. Customer loyalty rules!

2. Differentiating your organization from the competition: If a customer cannot tell the difference between your service and another, they will buy on price. A practice needs to invest in the things that highlight a unique benefit to the customer and deliver it with skill and finesse, like a concierge at a fine hotel. Identify and build on the qualities or characteristics which make your practice distinctive. Every customer, whether purchasing a car, hospital services, or endodontic care usually has a choice. Your job is to wind up in the referrers’ final consideration set and then be chosen because of your unique capabilities. It can range from a high-tech approach using a Web based patient intake process to digital radiography and microscopic imaging to non-surgical revision therapy to diagnosing a difficult case. Remember that technology implementation costs money, so do not market your practice as the best in town and then price it low, because you are sending a mixed message and wasting some of your marketing dollars. Learn what characteristics
make you office distinctive. If you are going to be a brand, you must be inexorably focused on what you do that adds value.

3. Establishing market leadership: First and foremost, communicate that you are a specialist. Make sure that patients understand that you have undergone extensive post-graduate training. Use verbal and written communication to focus attention on continually improving outcomes with the latest science by using evidence-based treatment that leads to a painless procedure with the highest level of success possible. Reveal the hidden by using models, drawings, and microscopic/radiographic imaging to increase the patient’s understanding of the procedure. For example, drawing a scaled diagram for each patient at the end of their visit will demonstrate your special skills. Be sure to let patients know that treatment you perform through the microscope is reflected through a mirror, so that every hand movement is reversed. Use technology to create a value proposition for all stakeholders—defined by modern management science as everyone with an interest in what the organization does, such as clients, employees, and vendors. Demonstrate your proficiency both singly and as a team, reaffirm the patient’s choice of endodontic treatment over extraction by addressing the benefits of decreasing dental disease to improve overall health, show sensitivity to patient’s mental and physical comfort, provide impeccable service, and offer superb facilities.44

One of the best ways to establish market leadership is to use state-of-the-art technology to create value in the referrer’s and patient’s mind that they can see and understand. Every patient treatment communication should reflect your technological competence. Digital radiographs and photographic images along with cogent narratives of treatment should reflect your commitment to the latest technology and help operationalize your brand. Performing a state-of-the-art procedure and then communicating the results by sending a film-based image and a few handwritten notes misses the opportunity to maximize your image as technologically sophisticated. This leads us to the next section about how to develop brand-building programs that are the most cost efficient, effective, and credible.

There are many ways to help define a brand. Volunteerism and community outreach programs are valuable ways to “give back” and also help your stakeholders understand your brand philosophy. The list of opportunities to partner with other professionals or community organizations is endless. Here are a few examples: (1) teaching at a dental school, (2) getting involved in philanthropic and civic organizations, (3) providing continuing education, (4) sponsoring a blood drive with the American Red Cross (Sidebar 2), and (5) partnering with another dental office to benefit a community program like a soup kitchen, food bank, and so on.

**USING TECHNOLOGY TO OPERATIONALIZE YOUR BRAND**

Although all endodontic practices provide basic specialty services to patients and referring doctors, it is the value-added services that can help differentiate your practice from competing practices. Research continues to link business success and professional achievement with developing long-term appeal and credibility. And adopting proven technologies is one of the most visible and reliable ways to create a positive impression and to continually engage patients, referrers, and staff, to say nothing of the clinical advantages.

Patients expect a high-tech approach to treatment. In fact, the National Health Information Infrastructure (NHII) is establishing a national electronic information network for health care. The NHII proposes to implement a computer-based patient record for most Americans by 2014.45 So how will your practice measure up? With the expanding use of technology in every aspect of life, patients expect their healthcare encounters to include the newest technologies. Use of the Internet to improve patient intake, receiving electronic receipt of patient pre-treatment radiographs and information, digital radiography, computerized charting, microscopes with imaging capability, instant communication of your treatment reports by email, online pharmacology information at the chairside, and music and entertainment options are all ways that your office can project a technologically advanced practice image. The list goes on and on, but the importance of differentiating your practice cannot be overestimated, and one of the best ways is with useful and visible technology.

“A brand strategy is a statement of the brand’s sustainable competitive advantage, usually consisting of a demographic and psychographic description of the intended customers and the benefits they get from the brand.”46 A brand-driven approach will create customer loyalty that will ultimately translate into a competitive advantage and increased profitability. Modern management science defines everyone with
an interest in what the organization does, such as clients, employees, and vendors are called stakeholders. And each interaction with a stakeholder must be understood and prioritized along the entire treatment cycle.

How important are employees to the branding process? The success of any branding strategy depends on engaging employees around your brand in a way that encourages ownership of the brand. We have all experienced the exceptional employee who understands the brand’s unique character and communicates it to all of the practice’s patients, for example, patients, referring doctors, and fellow staff members. Employees who are engaged around the brand confirm that the patient, referrer, and the brand are the things to focus on. It facilitates recruiting and retention of employees and improves morale, aligning each team member with your brand promise. All employees need to think, speak, and behave in ways that create the kind of patient and referring doctor experience that has lasting impact. Assimilating your brand among the employees of your organization will ensure that all employees understand and embrace your brand and can translate this into actionable behavior. This way employees become brand advocates that understand how his or her impact can affect satisfaction and ultimately loyalty.

Employee Motivation and Morale

Every business relies on its organizational values to deliver on its brand promise. Employee attitudes and
retention rely on a cohesive and upbeat culture. In order to develop brand advocates among all of your employees, your practice must first generate excitement about what it does. If each employee understands the benefits of modern endodontic treatment, it will reinforce their choice of employment. It can foster a sense of belonging to a profession they are passionately proud of. Employees need a leader who clearly understands the mission of the practice and can communicate his or her vision to each employee, patient, and referring doctor.

Brand-driven behaviors are enhanced by establishing a strong brand-based culture that is constantly fed and nurtured. It is crucial that your brand commitment is evident from the top down. If employees think that the practice leadership believes brand building is a priority, they will embrace it with the same passion. Each endodontist in the practice must communicate their endorsement of the practices’ brand vision so that every employee experiences appropriate modeling at every level of stake holder interaction. Without leadership support and willingness to lead by example, the old Russian proverb “the fish always stinks from the head downwards,” will resonate loudly.

Successful brand strategies require a clearly articulated vision of what your organization’s brand stands for and how to link it to your overall business strategy. For example, if employees are to bring the brand to life, a strategic foundation must be established. One important first step is to establish well-defined roles for your most important asset—your employees. The notion that your patient coordinator can just answer the phone, assign appointment times, and have customers fill out forms in the reception area will not lead to a patient-centered practice model that will generate a loyal following. There needs to be a conversation between the patient, referring doctor’s office, and your staff that is welcoming, informative, and nurturing. It is clear from the work of Silversen and the Werthlen Group that the better prepared a patient is before treatment, the more positive their treatment experience will be. Of course, our treatment must conform to the best available practices of the day, but also must provide the key satisfiers of the patient experience. In Bernick’s Harvard Business Review article about corporate culture, Alberto-Culver was able to boost sales 50% by creating a more customer-centered approach. It embraced a management culture that listened to its employees, celebrating events like birthdays and anniversaries, and creating passionate advocates of their brand. Without brand advocates, your practice will just muddle along, reducing the likelihood of reaching your desired future.

**BECOMING A LEARNING ORGANIZATION**

When you go to a barber shop or a salon to get a haircut, you tell the barber or hair stylist exactly how you want your hair done. After a few visits to the same person, he or she will probably know just how to shampoo, cut and, blow-dry your hair. You have invested time and energy to tell them how you want it, and they will have likewise invested in learning your preferences. In fact, the more you tell them about what you want, the more likely you will revisit the same hair stylist, because, after all, you have invested in them to create a mutual relationship. We have all experienced this kind of service and will tend to frequent the same establishment time and again because they have established a learning relationship. If you were to switch to another barber or stylist, you would have to make that investment all over again. According to Pine et al. in an article in the Harvard Business Review, customers “want exactly what they want – when, where and how they want it.” And a company that aspires to give customers exactly what they want must establish a learning relationship that ensures that all stakeholders collaborate. Developing learning relationships with referrers is critically important. The more you know about how they want it (new patients sent right over for consultation, one-visit treatment whenever possible, etc.), the greater chance that this referrer will continue to use your services. If you think about the cost of replacing one referrer with another, consider their lifetime value (LTV). LTV is the sum of the stream of profits attributable to this referrer. Take the average value of referrals in a year and multiply it by the projected number of years you intend to practice and you will see how important each referrer is to the bottom line.

New paradigms of patient care are emerging as the relationship between oral disease and systemic health become clearer. Developing a learning relationship with physicians is an emerging area that can enhance your professional image with non-dental sources of referral. In order to continually differentiate your practice, consider practice-building strategies that incorporate the latest research in endodontics or health care in general. Liaising with other healthcare providers is a good way to promote improved health and communicate your brand identity. Study clubs, continuing education opportunities, one-on-one meetings, Web sites, and publications can create valuable brand advocates.

**BRAND ASSIMILATION: PUTTING THE PROGRAM INTO ACTION**

The most successful organizations divide brand assimilation into three phases: strategic development, foundation building, and implementation. First, develop a strategic
plan that defines the scope and objectives of your program so that the right people and systems are identified to carry out your program. The second phase is foundation building, the process of aligning all employees around the central theme of your branding initiative through office workshops and reading. This is where each employee segment (e.g., chairside assistants and patient coordinators) learns about your brand initiatives and their role in communicating your message. The idea here is to guide behaviors that foster participation and allow all employees to understand the benefits of your key objectives. Implementation, the final phase, is where a range of tactics are employed to create key materials and talk about successes that will change employee behavior throughout the practice. As always, it is important to monitor the responses to your program and make changes as necessary.

Establishing a brand assimilation program will lead to a number of changes, but at what cost? How do you measure success? The first hurdle is to make sure that your employees understand your brand initiative. They have to be invested in developing significant relationships with your patients. When your employees assimilate your brand, you can begin to implement an action plan that markets your brand. One effective program can be an orientation luncheon for a referring office. Have all of the referrer’s office staff join your staff for a catered luncheon, conduct a brief office tour, and present a short program to let them know how you welcome new patients and how good communication between your offices can build patient confidence. The practice should strive to highlight the ways that both practices can work together.

Changes in organizational culture do not happen quickly. It takes a considerable amount of leadership and vision to promote meaningful changes to employee behavior. But the payoff will be a strong brand that will resonate with patients and referrers and help excite employees. This will ultimately result in increased loyalty.

While the detailed application of these disciplines is beyond the scope of this chapter, it is instructive to look at the relationship between providing services and recognizing the link between loyalty and profitability. The service-profit chain provides just such a model for operating in the medical environment. This is where leadership develops a dedicated team that provides superb service to patients that go on to develop loyalty to your organization.

When customers are highly loyal, there are minimal considerations of other brands. In the Xerox study quoted earlier, a survey of 430,000 customers revealed that highly satisfied customers were six times more likely to repurchase a Xerox product than merely satisfied customers. What is the take-home from this study? Simply put, the key to business success is to create as many loyal referrers and patients as possible. Then to market your practice in a way that not only maintains your most loyal referrers and patients, but attempts to increase their ranks by “marketing below the gold.” In other words, spend the bulk of your energy and precious marketing dollars taking a merely satisfied referrer and elevate them to the extremely satisfied category.

What are the benefits of loyalty? Patients will recommend your office to others. Hearing about how great your brand is from someone else will clearly be much more effective than self-promotion. Loyal patients are more accepting of new services, will say “no” to substitutes, and will pay a premium price for you to treat them. According to Passikoff, over 50% of customers would pay a premium of 20 to 25% before they would switch to another brand. The benefits of developing loyal patients cannot be overemphasized. It takes 7 to 10 times the cost to gain a new customer than to keep an existing customer. So do whatever it takes to retain your current patients. Remember that a service needs to do what is expected, as expected, for as long as expected throughout the customer experience.

Build on what differentiates you from the competition. If a patient cannot tell the difference between one service and another, they will buy on price. A practice needs to invest in the things that highlight a unique benefit to the patient and referrer and deliver it with skill and finesse, like a concierge does in a fine hotel. After all, patients and referrers really want just two things: results and process quality. The results part of the equation applies to a great diagnosis or root canal procedure, where the patient feels that he or she received caring service and state-of-the-art care and the referrer feels confident to complete their restoration. Process quality is how the referrer and patient were treated. Was the patient seen on a timely basis? Was the referral handled seamlessly? Was their treatment compassionate, respectful, and safe? Did the procedure make the referring clinician seem like everyone was on the same team?

Today’s consumers are increasingly brand-centric, and developing a brand identity is an important element in differentiating your services. The problem is how to get started so that you can deliver your brand across every touchpoint and every stakeholder. Begin by formulating a brand strategy that creates visibility and recognition, unaided recall, top-of-mind status, deep customer relationships, and build differentiation.
Deeply held values can be truly core values so fundamental and have only a few core values, usually 3 to 6. A company’s core values are most underleveraged and yet potentially powerful messages that a company puts out. Visionary companies tend to value back to your practice. First, determine your ways to drive sustainable, profitable, and long-term consistent with that point of view, even if they did not previously hold that belief. “Passion is a pretty fool proof test of whether a value is a core value,” says Mike Moser, an advertising and marketing expert. “It will help you include your heart in the decision-making process instead of just your head. Passion is what creates an emotional connection that transcends ads, public relations, brochures, or any other crafted messages that a company puts out.”

The brand–customer relationship remains one of the most underleveraged and yet potentially powerful ways to drive sustainable, profitable, and long-term value back to your practice. First, determine your practice’s core values. “Visionary companies tend to have only a few core values, usually 3 to 6...only a few values can be truly core values so fundamental and deeply held” that they will rarely change.

Every office has a personality, so maximizing the benefits of your practice by showing genuine warmth and sincere concern for the patient’s comfort are part of a thoughtful brand approach. Simple things like offering a warm, moist towel after treatment, providing appropriate music or video entertainment, and always using the most current technology are critical to establishing your brand personality. Always make sure your brand personality is appropriate for your audience. Is it predominantly male or female, blue collar, white collar, or service workers? Demographic studies have shown that endodontic patients are 60% female, average 48 years old, with 69% older than 40 years old.

BRAND TOUCHPOINT OVERVIEW

Like most world-class businesses, the best endodontic practices operate with a clear vision to ensure peak performance. Just like an Olympic hurdler who mentally previews his or her performance before an event, from leaving the starting block to breaking the finish line, each element in the patient’s visit must be carefully planned to ensure that patients feel they are in right place. Every staff member contributes to a successful visit by interacting with patients in a professional and caring way. It is useful here to visualize the patient and referring doctor experience as a continuum that begins with the introduction of endodontic therapy and only ends when the patient no longer needs your services. Dividing these interactions into three brand life-cycle stages, pre-treatment, treatment, and post-treatment procedures, each interaction can be choreographed to create a value chain that consistently fulfills the patient’s clinical and experiential needs. These steps are really brand touchpoints, or the different ways your services interact with patients, referrers, and fellow staff members. The members of your staff have to serve as brand ambassadors, and each interaction with patients and referring doctors must be consistent to ensure the best experience.

In order to be truly successful, every functional area in your organization must be responsible for bringing the brand promise to life. There must be total alignment between your organization and your brand strategy, so that you control the critical interactions your patients and referrers, or stakeholders, have with your brand. What are all the touchpoints that exist between your brand and a current or potential stakeholder? How can you create a brand-driven organization? Outlined below are 10 brand touchpoints commonly found in endodontic practices. Please note that only 5 of the 10 involve the practitioner, and only one of these involves the practitioner alone. The importance of selecting an outstanding staff and taking control of all patient and referring doctor touchpoints cannot be overemphasized.

1. Patient is informed that they need endodontic treatment: The process begins when the patient is advised that he or she needs an endodontic consultation. Providing each referrer with a kit that contains your office brochure, referral forms, appointment cards, business reply envelopes, and Web site information will help introduce patients to your practice. According to Jack Silversin, in his American Association of Endodontists-funded study to learn about the endodontist–patient relationship, the more your patients know about their treatment in advance, the better their treatment experience will be.

2. Patient calls for their first appointment: When a new patient calls for an appointment, complete a written telephone intake form or software-based pre-registration form, and set up an initial appointment. The telephone intake form should be designed with a sequenced set of questions in order to get efficiently critical information and document that all pre-treatment instructions were given.

Telephones are an essential part of the new patient experience, so make sure that proper telephone etiquette
is practiced at all times. According to Albert Mehrabian, a pioneer in communications research, there are three elements to any face-to-face communication: words, tone of voice, and body language. When it comes to feelings and attitudes, approximately 7% of meaning is in the words that are spoken, 38% of meaning is paralinguistic (the way that the words are said, like smiling on the phone), and 55% of meaning is in facial expression. The telephone creates an immediate communication gap because facial expression is not apparent, so the words and paralinguistic attributes take on added importance.

New patients should be queried about their status, because patients in pain and/or swelling are interested in immediate treatment and will generally accept scheduling at the convenience of the office. These patients will ideally need to be appointed the same day they call. Patients who have no discomfort or mild discomfort will generally be interested in convenience.

There are several methods available to provide pre-treatment information. Invite new patients to view your office Web site, where they can complete a secure patient registration and health history form. Web sites are necessary, if not a necessity, in today’s healthcare environment. According to Harris Interactive, in a poll of 1,015 US adults conducted in 2005, 72% search the Internet for health-related information. Almost 58% report looking for information often search the Internet for health topics and only 14% say that they hardly ever search health topics. Even more remarkable, 85% of those who have ever searched the Internet for health-related information did so in the last month of the study, and now averages seven searches each month per patient. What does this mean to the endodontic practitioner? Today, patients expect to meet their prospective practitioner on the Internet. Mailing, faxing, or emailing a “welcome kit” to patients with a welcome letter, brochure, procedure explanation, doctor biography, financial policy, registration, health history form, and map are also valuable ways to streamline new patient intake. Creating a Web site to provide patient education opportunities, contact information, and referral materials will further enhance pre-treatment preparation and provide the most convenient and cost-effective solution. While society is becoming more accustomed to automation and the advantages it provides, “dentists must be careful not to allow technology to interfere with the relationship between patient and doctor and the patient and staff.”

If the office must meet the requirements of HIPAA, all online transactions, as well as the office network, must be secure. If the office uses a wireless network, appropriate security measures are required.

3. Patient arrives for first visit: When patients arrive for their initial visit, be prepared and give them a warm and sincere welcome. Patients can complete their registration on a reception area computer kiosk connected to the practice’s network or the Internet, or fill out paper-based forms and view educational materials while in the reception area. This is the time for scanning any film-based radiographs or appending digitally transmitted images into your radiographic database, if applicable. Some endodontic software can allow front office personnel to indicate the patient’s status from their arrival at the office and transitioning through treatment and finally discharge. Besides depicting the status of each patient in the office, recording the chair time for each type of procedure will allow create metrics that can be used to measure profitability.

4. Patient is escorted to operatory: Escorting patients to the operatory is an opportunity to connect staff and patient. Employee name badges and a policy of each staff member introducing himself or herself to the patient by name should be practiced at all times. Also, chance encounters in the office where a patient is within five feet should prompt a “hello” greeting.

When the patient is seated in the dental chair, the patient’s individual record should appear on the chairside computer screen in the operatory, maintaining HIPAA compliance, and assuring the patient that your efforts will be focused on them. Once seated, the assistant should confirm that the patient has followed all pre-treatment instructions, including their antibiotic pre-medication regimen if any, other pre-treatment medications, and have eaten breakfast or lunch to ensure a normal blood glucose level, whichever is appropriate. Of course, staff should confirm that all prescribed medications have been taken on schedule, and if sedation is contemplated, an escort is present to accompany the patient after treatment completion. This is the time for your staff to tell the patient what comes next and set their expectations for their visit. Assuring that their comfort is of utmost importance, offering a blanket or pillow, describing what treatment will be performed, length of the visit, and so on are all important. Acknowledge and reassure the patient that his or her concerns will be addressed. This is also the time to project a safe practice image. Sanitize your hands in front of the patient or let them know you are leaving the operatory to wash. Wear proper clothing and limit masks, gloves, and other protective gear to the clinical areas of the office. It is incumbent on the endodontic practitioner to convey a sense of safety throughout each visit.
This is the time for the dental auxiliary to record the chief complaint, history of present illness, medical history and review all current medications. Once the general area of interest is determined, the auxiliary should expose dental radiographs, record photographic images, take vital signs, answer questions, and, most importantly, comfort the patient. Each staff member should be dressed and groomed appropriately, scripted for this interaction, with the best answers to commonly asked questions to promote consistency and accuracy. Of course, all medications should be recorded in the patient’s database so new prescriptions can be automatically checked for advised interactions and cautions.

5. Doctor consults with patient: After introduction by the dental assistant, you should establish eye contact, make sure the patient is comfortable, listen attentively without interrupting, and according to MaryJo Ludwig64 Clinical Faculty, Department of Family Medicine at the University of Washington Hospital, “acknowledge and legitimize feelings, explain and reassure during examinations, and ask explicitly if there are other areas of concern.” First impressions are important, and your first contact with the patient is no exception. Psychiatrists Leonard and Natalie Zunin,65 stated in their book “Contact: The First Four Minutes,” that, on average, there is only a short moment in time, a 4-minute window, “to grab someone’s attention and establish credibility and rapport.” These first impressions demonstrate our compassion, care, intelligence, attention to detail, and pride. Be sure to limit the time you spend with the computer at the expense of eye contact and personal interaction with the patient. Once the patient’s dental needs and intake data are reviewed, the initial oral exam is completed, a discussion and informed consent can take place. According to Peter Sfikas,66 chief legal counsel of the ADA, the ADA’s Code of Professional Conduct requires dentists to “inform patients of proposed treatment and any reasonable alternatives in a manner that allows the patient to become involved in the treatment decision.” Every dentist should understand the requirements of their state practice laws with regard to informed consent. In this regard, states differ greatly. In Pennsylvania, for example, a court ruling held that orthograde endodontic treatment was a surgical procedure requiring written informed consent, while treatment considered non-surgical in nature does not require informed consent. Conversely, courts in New Jersey require dentists to provide informed consent even for non-invasive procedures. Also, a patient’s refusal of recommended treatment should be documented in writing to ensure that the patient comprehends the possible consequences of refusing treatment. After the discussion and informed consent processes are completed, any additional pre-operative issues should be addressed. Any patient who has not eaten a timely meal and will receive local anesthetic should receive an appropriate nutrient supplement to avoid syncope from low blood glucose levels. Ensure® and Glucerna® are lactose-free drinks designed for occasional meal replacement and intended for non-diabetic and diabetic patients, respectively. If non-steroidal anti-inflammatory drugs or antibiotics are indicated, they can be dispensed at this time.

6. Doctor treats patient: Every effort should be made to include the patient in the treatment process. Confirm that all of the patient’s questions are answered. Then treatment can be initiated along with documentation of the visit. If digital scheduling is available, patients can be reappointed while still in the operatory and their insurance information can be sent to the office financial coordinator via the network or directly to the insurance company, if the office LAN integrates with the Internet.

7. Doctor discharges patient: Once the treatment is completed, the final 4 minutes should focus on the patient and their post-operative instructions. Communicate that you are a specialist by drawing a scaled diagram for each patient at the end of their visit that explains the intricacy of your procedures. Use technology to create a value proposition for all patients. In the end, be sure to take every opportunity to complement the patient on their cooperative attitude. Medications can now be dispensed, as necessary, and prescriptions selected and sent to the printer.

8. Patient is escorted to front desk: Patients are then escorted to the office departure station and reintroduced by their escorting assistant to the patient coordinator. Sit-down departure stations at the front desk will serve to increase patient comfort and to better accommodate disabled patients. In some endodontic offices, advanced practice management software will allow the clinician or assisting staff to forward all pertinent billing statements and post-operative instructions to the front desk computer with a few mouse clicks.

9. Patient is checked out: Once the patient is brought to the departure station, they are asked the “1, 2, 3 questions”: (1) The patient coordinator asks the
patient how they are feeling; (2) Next, the patient receives customized instructions, which outline their post-operative instructions and an explanation of check-up recommendations. Patients are then appointed for their next visit and receive any prescriptions and a patient satisfaction survey with a business reply form centered on the reverse side for mailing convenience; (3) Lastly, patients are asked to satisfy their financial obligation.

A business reply permit can be obtained from your local post office at a nominal cost. Patients can either fill out the form immediately (highest response rate) or return it by mail. If patients are invited to fill out the form in the office, a box should be available for the completed survey. Because people often feel awkward expressing their real views, this anonymity will improve compliance.

Measuring patient satisfaction will provide two main benefits: (1) it will allow patients to vent about issues that will ultimately affect their loyalty and their likelihood to return for additional treatment, and (2) surveys present valuable feedback about what really works and what doesn’t. All too often, we are providing what we want to and not what the patient deeply values. In a recent 2-year examination linking customer satisfaction with purchasing behavior, and ultimately with company growth, Reichheld concluded that the likelihood of a customer recommending your services to a colleague or friend was directly related to increased growth.

Patient treatment reports and other correspondence can be created by the front desk or assisting staff, reviewed by the practitioner, and then transmitted to a printer and/or email client for distribution to referrers. It is important for the patient to list all of their co-therapists during registration, so they will automatically receive the final treatment reports.

10. Doctor telephones patient in evening: The last touchpoint is the evening phone call by the practitioner to the patient. The value of this call cannot be overemphasized, as it is one of the most appreciated services reported by patients on their satisfaction surveys.

Remember that patients want to be treated in a clean and welcoming office environment. They evaluate your office on a continual basis, and educating your patients about the safety precautions you take will add value. Always assure patients that their comfort and safety are major objectives of their treatment. Try to explain the procedure, with permission, to the patient in terms they can understand. Use every opportunity to further establish your technological leadership by making them a partner in their treatment. The relevance of your brand involves reverse thinking. You need to “move out of your world and into theirs.” It is not what you are selling; it is what they are buying, that counts!

DEVELOPING A CULTURE OF EXCELLENCE AROUND YOUR BRAND

The operation of the practice can be managed by asking a key question: How can I be excellent? And the answer is by designing systems that allow you to do the job right the first time. Creating a strategy to achieve success requires five basic steps, each dependent on the preceding step to accomplish your goals.

1. Step 1: Identify which patients you really want. Begin with a clear understanding of who your patients are and which ones you want to serve.

2. Step 2: Identify what your targeted referrers and patients deeply value. All purchasers of services or products want results and process quality. Finishing treatment with a pain-free and fully functioning tooth is the results part. And having a positive experience where respect, timeliness, courtesy and treatment with all needs (in the mind of the patient or referrer) met on a consistent basis is the process quality part of the equation.

3. Step 3: Develop a “customer-centered focus.” Learn to manage the convergence between what your patients deeply value and the things that you do best. This means that the core procedures are performed in a caring and expert manner. Focus on the routine procedures that lend themselves to the highest levels of success with the most profit.

4. Step 4: Make “creating a customer-centered focus” your mission. Your mission is your “compass” in an increasingly challenging practice environment. This means understanding your mission and how each stakeholder will support and interact with the mission. Everyone needs a program that they can own, but be ready to change on a routine basis.

5. Step 5: Create an organization-wide obsession with your mission. To become consistent and successful, communicate your mission to your staff, your referring doctors, and patients. In fact, brands demand consistency. According to Straine and Straine, “If your receptionist is rude, if your office manager is unhelpful when a patient needs financing, if your policies are always changing, the negative impact on your brand” will destroy your efforts to achieve clinical excellence.
“QUALITY IN FACT” AND “QUALITY IN KIND”

Another important concept that will help the empathize with patients and referring doctors is the concept of treatment quality as viewed from the patient perspective. In a look at quality, former Malcolm Baldrige Award examiner Patrick Townsend\(^\text{71}\) defines \textit{quality in fact} as goods or services that measure up to the specifications of the provider. For example, when an endodontic procedure is completed, does it meet all of the desired specifications as defined by the practitioner? Are all of the canals identified, cleaned, shaped, and obturated to completely seal the root canal system? If so, then the procedure meets the specifications of the provider and satisfies the criteria of a satisfactory case. But that is only half of the story. The other half is defined by the authors as \textit{quality in kind}, or the way that the patient perceives the procedure—from their viewpoint. For patients, a successful visit will hinge on how the patient was treated, because the success of the procedure will be judged on the subjective quality as the patient sees it, or the experiential aspects of their visit. And do not short change the importance of the physical environment of the office. If the office looks tired, patients will respond in kind, because patients will “judge the book by its cover.” There is no way for most customers to even begin to assess the quality of the endodontic treatment they receive, they can only judge by how they were treated, the appearance of the office, and other non-technical aspects of their treatment. Take a quick mental journey through your office, reception area, front desk area, hallways, sterilization area, and operatories. Do they reflect your intended practice image? Are they modern, clean, efficient, organized, and calm? Does it send the message that your practice is up-to-date? Pay attention to the details—your patients and referers are. Remember, you do not get a second chance to make a great first impression.

UNDERSTANDING SATISFACTION

A typical business customer satisfaction index is shown in Figure 1. If the satisfied and completely satisfied patients total 81%, should the directors of this company be content? Should a business concentrate its resources on increasing the satisfaction of the very dissatisfied patients or try to raise the merely satisfied customer to a completely satisfied level?

Studies have shown that it is far cheaper to raise the customer with a satisfaction index of from between 3.5 and 4.5 to a 5 than move a very dissatisfied customer to a higher level.\(^\text{72}\) Many businesses spend a disproportionate amount of resources on a small percentage of customers who are almost impossible to please. Pursuing these customers also may hurt company morale and will disparage the company to other potential patients.

What impact will this have on an endodontic practice? Referring doctors and patients who enjoy complete satisfaction with your services are more likely to be loyal “apostles” of the office than those who are just satisfied.

Professor James Hasket\(^\text{73}\) of the Harvard Business School, in his ground-breaking research on the “satisfaction-loyalty link,” states that “if employee performance and loyalty is good within an organization, then that organization’s customers will be more likely to repurchase a product or service.” One way to measure the satisfaction of your referring doctors and customers is to use a satisfaction survey. This tool, outlined in more detail above, can point out areas that you can improve, such as front desk operations, office hours, parking, and so on.

Once you have identified areas that need corrective action, be prepared to create an action plan to fix the problem. Remember, a problem exists if a referring doctor or a patient perceives a problem. Problems can be fixed and loyalty maintained if the problem is fixed quickly. It has been shown that 95% of customers will repurchase a product or service if the problem is fixed on the spot, and 78% of customers will repurchase if the problem is fixed within 24 hours.

Every patient and referring doctor should receive the basic elements they expect, like a professionally performed and technologically advanced procedure. Everyone receives the basic support services that include instructions, assistance with financial arrangements, and insurance filing. Everyone gets the basic recovery help that includes an apology for an appointment delay or correction of a billing error. But only certain referers will get extraordinary services that excel in meeting their personal preference that make the service seem customized. An example of the extraordinary services you might provide to a core referer might be treating a patient for his or her convenience on a Saturday for non-emergent treatment when you normally do not conduct business on a weekend.

PATIENT SATISFACTION SURVEYS

Patient questionnaires seek explicit information that can be analyzed and trended over time. Patient opinion surveys can help determine satisfaction with office personnel, procedures, or other aspects of the practice which may ultimately affect patient and
referring doctor loyalty. Opinion surveys can be customized to fit the needs of each practice and allow customers to vent if there are problems.

Several options are available, each of which can be integrated into broader Total Quality Management (TQM) initiatives or performance assessment strategies. Surveys can be short in-office questionnaires, with each patient filling out a form while in the office, or longer take-home questionnaires. Anonymity may prompt patients to be more honest with their feedback. If identity is disclosed, the surveys can include call-backs to patients after they have returned home. They can even involve focus groups to investigate very specific questions about programs, services, and staff. Other forms of surveys include mail and email surveys, sent to a random selection of patients. These survey channels may give the patient more time to complete the survey, which may result in a more in-depth response.

The most personal way to conduct a satisfaction survey is in person or by telephone. You can have a staff member or research professional perform the survey. Patients can more easily elaborate on their responses, but these types of surveys can be expensive.

In recent research published by Press Ganey Associates to evaluate healthcare satisfaction, patients rated the courtesy, friendliness, and professionalism of the dental assistant as more important than that of the dentist! Infection control and cleanliness was rated second. While the dentist’s skill was important, the dentist’s attention to patient anxiety and concerns were directly related to patient loyalty and their potential to refer other patients. Patients also rated the amount of time spent with a patient and explanation of treatment options as important indicators of practice quality.

Installation of a bulletin board at your office to allow clinicians and staff to read each survey is an easy way to share comments and build a consensus. Many surveys reinforce employee behavior, especially if they mention a staff member by name. Each survey is an opportunity for your organization to improve.

CREATING A WEB SITE, STATIONARY, AND BROCHURE
One of the most often neglected parts of an office branding program is the production of Internet resources and coordinated office publications. Internet technology is advancing at a record pace. In every field, including dentistry, entrepreneurs are using it to devise new and better ways to develop business and lower costs. To ensure brand awareness in the future, endodontists must acknowledge the enormous potential of this technology and develop sound strategies for harnessing all its capabilities. In the larger context, an Internet site can be part of your overall identity management program that ties together all marketing materials to communicate your practices vision. Using a professional design firm to create your Web site, stationary, and brochures will ensure a coordinated look that will be more powerful than unmatched pieces. Internet technology can enable your practice to broaden the scope of patient relations and increase communications with patients, referring doctors, and study clubs. Over the last few years, the Internet has become a unique medium for the endodontist to promote innovative and technically sophisticated treatment.

Getting started on a Web site can be a challenging because there is a tendency to keep changing, and the possibilities are virtually limitless. Here are some pointers to help you get started:

1. The best way to begin is to visit other medical and dental provider’s Web sites. Learn how to navigate their site, what elements are required and if you want to include programs with more high-end graphic effects. Simple is better, but patients and referring doctors will want to see some “eye candy” and learn on each visit. Video segments featuring you and your staff are becoming more commonplace as video technology over the Internet improves.
2. Decide on your goals. Is it to generate referrals via Internet search engines, develop links to sites that market dentists, or serve as a resource for your patients and referring doctors?
3. Work with Web site professionals to create a design for your site. Remember that the design of the site should complement the image you are trying to project. Also, consider employing search engine optimization techniques to make your site more prominent.
4. Outline your proposed site and create a storyboard that includes navigation possibilities for your audience. Design every page on a separate piece of paper and test your ideas with friends, selected patients, and referring doctors.
5. Choose a Uniform Resource Locator (URL) so that Internet address can be easily remembered and entered in a browser with a minimum of effort and confusion. The URL should tie into your desired image.
6. Then just fill in the blanks with copy, photographs, and an appealing style that projects your vision. Keep it fresh. If you want repeat visitors,
continually update the site and make sure your
links are relevant and functional.

Human Resources
Organizational success in endodontic practice requires
a high-performance staff. After all, your employees
are your brand. They must understand what your
brand stands for and how to deliver on your brand
promise. Pfeffer and Veiga observe that “there is a
substantial and rapidly expanding body of evidence,
some of it quite methodologically sophisticated, that
speaks to the strong connection between how firms
manage their people and the economic results
achieved.” Exactly how important is marinating a
well-trained and dedicated staff? Recent studies looked
at 968 firms representing all major industries and found
that just a 7% decrease in employee turnover resulted in
a per employee increase of $27,044 more in sales and
$18,641 more in market value. It is clear that any
business, including an endodontic practice, can benefit
by adopting employee-related best practices to ensure
financial success and ultimately clinical excellence.

According to Pfeffer and Veiga, the most important
elements of a successful HR management program are
(1) providing long-term job security to assure that
employee efforts will be rewarded; (2) recruiting and
hiring the right people from the beginning; (3) creating
self-managed project teams of peers to increase their
sense of responsibility and accountability; (4) providing
high compensation that is contingent on performance;
(5) investing in extensive training for all employees; (6)
reducing status differences between employees to
improve idea generation from all employees; and (7)
teaching information sharing to create a high-trust
organization that allows inclusiveness.

JOB DESCRIPTION
The largest cost items for most endodontic practices is
employee wages and benefits. The plethora of reg-
ulations, such as equal employment opportunity (EEO) legislation enacted by local, state, and federal
governments, has made job analysis a mandatory part
of HR management. One of the most useful products
of comprehensive job analysis is the job description,
an Americans with Disability Act (AwDA) compliant
narrative of the major responsibilities and duties asso-
ciated with each job. While most job descriptions are
limited to a single type of service or project, many
endodontic offices require the use of cross-functional
team members to complete certain tasks or to fill-in
for a vacationing employee.

A good starting point is to consult O*NET, a US
Department of Labor (DOL)-sponsored comprehen-
sive source for continually updated information on
occupational characteristics. Based on the most cur-
rent version of the Standard Occupational Classification System, each O*NET occupational title and code
includes descriptors for skills, abilities, knowledge,
tasks, work activities, work context, experience levels
required, job interests, and work values. A partial
sample of O*NET’s listed tasks, knowledge, and abil-
ities section for dental assistants (code 31-9091.00) are
summarized in Table 3.

THE STANDARD OPERATING PROCEDURE
Often overlooked but extremely valuable, the standard
operating procedure (SOP) is a written practices and
procedures reference, which is designed to ensure that
key procedures are performed in a safe and compliant
manner. The SOP is typically written by the current
job holder and edited by the practice administrator. SOPs force employees to think through a procedure
<table>
<thead>
<tr>
<th>Importance</th>
<th>Category</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>Core</td>
<td>Prepare patient, sterilize and disinfect instruments, set up instrument trays, prepare materials, and assist dentist during dental procedures</td>
</tr>
<tr>
<td>92</td>
<td>Core</td>
<td>Expose dental diagnostic X-rays (certification may be required)</td>
</tr>
<tr>
<td>90</td>
<td>Core</td>
<td>Record treatment information in patient records</td>
</tr>
<tr>
<td>88</td>
<td>Core</td>
<td>Take and record medical and dental histories and vital signs of patients</td>
</tr>
<tr>
<td>98</td>
<td>Core</td>
<td>Provide post-operative instructions prescribed by dentist</td>
</tr>
<tr>
<td>87</td>
<td>Core</td>
<td>Assist dentist in management of medical and dental emergencies</td>
</tr>
<tr>
<td>77</td>
<td>Core</td>
<td>Instruct patients in oral hygiene and plaque control programs</td>
</tr>
<tr>
<td>79</td>
<td>Supplemental</td>
<td>Apply protective coating of fluoride to teeth</td>
</tr>
<tr>
<td>76</td>
<td>Supplemental</td>
<td>Schedule appointments, prepare bills and receive payment for dental services, complete insurance forms, and maintain records, manually or using computer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Importance</th>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Medicine and Dentistry—Knowledge of the information and techniques needed to diagnose and treat human injuries, diseases, and deformities. This includes symptoms, treatment alternatives, drug properties and interactions, and preventive healthcare measures</td>
</tr>
<tr>
<td>73</td>
<td>Customer and Personal Service—Knowledge of principles and processes for providing customer and personal services. This includes customer needs assessment, meeting quality standards for services, and evaluation of customer satisfaction</td>
</tr>
<tr>
<td>64</td>
<td>English Language—Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar</td>
</tr>
<tr>
<td>59</td>
<td>Clerical—Knowledge of administrative and clerical procedures and systems such as word processing, managing files and records, stenography and transcription, designing forms, and other office procedures and terminology</td>
</tr>
<tr>
<td>51</td>
<td>Chemistry—Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods</td>
</tr>
<tr>
<td>42</td>
<td>Computers and Electronics—Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming</td>
</tr>
<tr>
<td>40</td>
<td>Psychology—Knowledge of human behavior and performance; individual differences in ability, personality, and interests; learning and motivation; psychological research methods; and the assessment and treatment of behavioral and affective disorders</td>
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<tr>
<td>40</td>
<td>Public Safety and Security—Knowledge of relevant equipment, policies, procedures, and strategies to promote effective local, state, or national security operations for the protection of people, data, property, and institutions</td>
</tr>
<tr>
<td>36</td>
<td>Mechanical—Knowledge of machines and tools, including their designs, uses, repair, and maintenance</td>
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<table>
<thead>
<tr>
<th>Importance</th>
<th>Ability</th>
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<tbody>
<tr>
<td>78</td>
<td>Oral Expression—The ability to communicate information and ideas so others will understand</td>
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<tr>
<td>75</td>
<td>Oral Comprehension—The ability to listen to and understand information and ideas presented through spoken words and sentences</td>
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<tr>
<td>72</td>
<td>Near Vision—The ability to see details at close range (within a few feet of the observer)</td>
</tr>
<tr>
<td>72</td>
<td>Written Expression—The ability to communicate information and ideas in writing so others will understand</td>
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<tr>
<td>66</td>
<td>Information Ordering—The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (e.g., patterns of numbers, letters, words, pictures, and mathematical operations)</td>
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<tr>
<td>66</td>
<td>Speech Clarity—The ability to speak clearly so others can understand you</td>
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<tr>
<td>62</td>
<td>Arm-Hand Steadiness—The ability to keep your hand and arm steady while moving your arm or while holding your arm and hand in one position</td>
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<tr>
<td>60</td>
<td>Speech Recognition—The ability to identify and understand the speech of another person</td>
</tr>
<tr>
<td>56</td>
<td>Finger Dexterity—The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects</td>
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<tr>
<td>56</td>
<td>Problem Sensitivity—The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem</td>
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<tr>
<td>56</td>
<td>Selective Attention—The ability to concentrate on a task over a period of time without being distracted</td>
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<tr>
<td>56</td>
<td>Written Comprehension—The ability to read and understand information and ideas presented in writing</td>
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<tr>
<td>53</td>
<td>Flexibility of Closure—The ability to identify or detect a known pattern (a figure, object, word, or sound) that is hidden in other distracting material</td>
</tr>
<tr>
<td>53</td>
<td>Manual Dexterity—The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects</td>
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Table 3 continued on page 1499
step by step and are in themselves useful training tools. More complex tasks lend themselves to the SOP structure for training new employees and modifying procedures to improve efficiency and safety. While SOPs work well for procedures that require safety and standardization, they may limit creativity where imagination is warranted. The best approach is to be concise and make the document as dynamic as possible. SOPs should be easily accessible to all employees via the practice’s computer network and at a minimum should be updated on an annual basis. Each SOP should have a header with the title, original issue date, revision dates, number of pages, the author of the SOP, and “approved by” signature plus the following basic elements (Table 4):

1. Desired outcome 
2. Definitions 
3. Measurement 
4. General information 
5. Step-by-step procedure with identification of critical information 
6. Attachments and forms to be used, if any

**CREATING THE EMPLOYEE HANDBOOK**

Employee handbooks help to establish the employer’s expectations and can prevent misunderstandings that may reduce the risk of litigation. Because most employees want to be successful, they will generally welcome a description of expectations, procedures for obtaining a promotion or raise, policies on dress, leave requests, work hours, disciplinary issues, and other important guidelines. The process involved in creating a handbook can also help you think through and establish your own unique policies. To aid in the process, consider getting professional advice from your attorney, accountant, or a personnel advisory firm, so that personnel procedures are documented before contentious issues arise. Personnel advisory firms can provide comprehensive and cost-effective help and implementation, providing excellent handbooks, supporting resource manuals, and technical assistance. The ADA also sells a handbook resource manual with step-by-step guidance.

Courts generally view both verbal and written policies as a contract. However, unwritten policies may pose more risk than written policies, because verbal policies either can be implied or given by someone with no authority. Written handbooks help avoid conflict by reducing the chances of a dispute between you and employee, especially in the most litigious areas of firing and discipline. It is critical that your handbook is properly vetted by knowledgeable advisors, because, as Peter Sfikas, ADA general council notes, courts “have determined that manuals, handbooks and booklets can create implied employment contracts, subjecting the employer and employee to additional terms and conditions of employment.” In the interest of both the employer and the employee, written handbooks that clearly state the policies of the practice serve to minimize the risk of litigation, and well-drafted disclaimers may help to maintain the “at will” status of employees. Generally, a clear statement at the beginning of the handbook stating that the handbook is not a contract and that the policies therein can change at any time without advanced notice will provide some measure of protection.

According to the U.S. SBA, an employee handbook should include the following:

1. Overview of practice philosophy and history
2. Equal opportunity statement that hiring, promotion, pay, and benefits are not related to employee’s
Table 4 Standard Operating Procedures: Computers

| Desired Outcome: All computer equipment in the Practice will operate efficiently to create and store all radiographic and visible light images, clinical charts, patient financial transactions, appointments, protected health information (PHI), and other materials related to the Practice. Patient confidentiality will be maintained in accordance with the Practice’s current Health Insurance Portability, and Accountability Act (HIPAA) Manual and office policies.  
| Definitions: Information technology (IT) refers to the use of computers and computer software to manage office information.  
| Measurement: Evaluation of internal and external customer satisfaction by “Employee Evaluation of Office” and “Patient Satisfaction Survey.” Internal customers will experience infrequent computer down time, undergo adequate training, and use programs that do the intended job right the first time.  
| Introduction: All computer systems in the office are critical to the success of the Practice. The Practice stores all clinical and administrative data on the office computer system. Therefore, the Practice’s computers and networks are to be used for Practice-related work only.  
| No expectation of privacy: In the course of operation and maintenance activities, use of computers and networks may be monitored to ensure the continuing effectiveness and integrity of the Practice’s IT resources. Email, Web logs and data, and other files created or received while using the Practice’s computers are neither private nor confidential. The Practice reserves the right to access and disclose all messages sent by its computers and networks, as well as any data created, received, or stored on them.  
| Computer security and access to files and email: Although the Practice intends to convey no expectation of privacy, its business communications must be protected from unauthorized access. At no time may any employee remove or transfer any data to computers outside of the office by any means, including disks, jump-drives, CD-ROMs, or the Internet for any reason. Employees are not to give any computer information to anyone on the telephone who calls our office without specific permission from Dr. Levin or Dr. Lee. The only exception is our IT services company. No disks, CD-ROMs, or other material of any kind can be brought from the home of an employee and placed on the Practice’s computer systems at any time.  
| Patient confidentiality: see HIPAA Manual and office policies as published periodically.  
| Internet use: No employee is allowed to use the computer system for personal use at any time.  
| Web: When using the Web, only the approved Internet browser is permitted. Approved sites include only those directly related to the business of the Practice.  
| Email: Only MS Outlook, Google, and Yahoo are approved for email use. Any email messages generated or viewed at the office are the property of the Practice.  
| Virus protection: We use McAfee Enterprise virus protection, which automatically updates all of our workstations every night via the McAfee Web site and our LAN. All computers will be running McAfee virus protection at all times. This will protect our system from virus destruction and other potentially harmful computer intrusions. Confirm that this software is active at start-up and remains active at all times.  
| Firewall protection: We are protected from hackers through our Internet switch called WatchGuard “Firebox.” Make sure this equipment is on at all times.  
| Backup: We use a tape backup system, located in the server. Each business day, a numbered tape is placed in the server and noted on the “Backup Log” by the operator’s initials. Every Friday, the cleaning tape is placed in the tape drive, allowed to complete one cycle that takes approximately 1 minute, and is removed from the drive. On Monday, the Friday night tape is placed on Dr. Levin’s laptop bag for off-site storage.  
| Passwords: Each employee will be issued a discrete user name and password to log into EndoVision. As there are nine levels of security, some codes will not allow every user to perform all tasks.  
| SQL: EndoVision (EV) and Schick (CDR) use their own database engines that reside on the server. This SQL database software must be active on the server to allow workstation access to EV and CDR. Both of these SQL database engines will be running on the “Taskbar” of the server. If you cannot login from any workstation for either EV or CDR, check the server to see if their individual SQL database engines (icons in the taskbar) are active.  
| PC software and hardware controls: Users may not download, purchase, or install software or hardware on office computers unless it is approved by Dr. Levin or Dr. Lee. Copyrighted and licensed materials may not be used on a PC or the Internet unless legally owned or otherwise in compliance with intellectual property laws.  

Critical information is italicized.

race, color, religion, sex, age, disability, or national origin.  
3. Work hours should be defined, including time for lunch and conditions that could require late hours, such as treating after-hours emergencies.  
4. Wage policies should include general information about when paychecks will be issued, how and when promotions are handled, classification of part-time, full-time, and on-call employees, overtime, loans, and leaves without pay.  
5. The performance review section should describe how and when employees will be evaluated; unscheduled evaluations may be made at any time to advise employees of unsatisfactory work.  
6. Paid holidays and all types of leave, including family (maternity, adoption, and elder care), medical, dental, funeral, personal, jury, and military should be listed.  
7. A termination section should inform employees about causes that will trigger firing, including criminal activity, insubordination, absenteeism, and poor work performance.  
8. All forms should be included, such as sample requests for vacation, medical leave, hepatitis vaccination declination, and so on.
9. Acknowledgement of receipt and reading of handbook by employees should be required by the practice and kept in the employee’s personnel folder or other secure location.

Employee handbooks should be written by a lawyer specializing in employment law or by consultants who provide HR advice. A poorly written handbook may contain legal pitfalls that can lead to litigation. The following suggestions may help avoid some common errors:

1. A statement that conforms to your state’s “employment-at-will” doctrine, which specifies that employment can be terminated at any time, for any reason, or no reason at all, will generally provide some measure of protection against successful litigation. Good advice here is critical, because construction of the document, obtaining written acknowledgement by the employee, public policy exceptions, situations where an expressed or implied employment contract exists, and “situations where an implicit duty of good faith exists in the employment relationship” can lead to confusion and ultimately to litigation.

2. Announcing a “probationary period” of employment may wrongly imply that employees are entitled to continuing employment after the probation period is over.

3. Employee manuals should not include benefit plan documents, but simply point employees toward other documentation.

4. Do not outline specific pre-firing procedures, because courts have held employers liable for “wrongful termination when those steps were not followed.”

5. Generally, paychecks must be paid within a specified time limit, so be sure to specify these guidelines in accordance with local wage and hour laws.

6. Ensure that employees sign an acknowledgement that they have received, read, and agreed to the provisions of the handbook. Otherwise, an employee may claim that he or she never received the manual.

7. Limitations on employee–employee communications about wages or benefits are not allowed.

The employee handbook should be a positive tool for promoting better communication and improving morale. Be sure to review the handbook at least annually to be sure it is consistent with office policies. Also, annualizing employee performance reviews, raises and updating state and federal withholding forms to coincide with the date of hire for each employee, will help improve compliance by the practice.

EMPLOYEE SELECTION CRITERIA
What are the predictors of the best job performance? In an article reviewing 85 years of the practical and theoretical implications of personnel psychology, researchers Schmidt and Hunter have shown that, on average, intelligence or general mental ability (GMA) is the most useful primary personnel measure for hiring decisions when compared to all other attributes, including conscientiousness. The positive economic effects of assessing an applicant’s intelligence and hiring only the top performers cannot be overestimated. Furthermore, this study states that performance in a skilled job will benefit more from a higher GMA than performance in a semi-skilled job. It turns out that people with a high GMA scientifically correlate with conscientiousness, agreeableness, and emotional stability.

Other studies have demonstrated that while intelligence is the best single predictor of performance, screening employees for how well their values fit with their employer’s values (value fit) is also a predictor of employee satisfaction and retention. However, when interdependent tasks were measured against non-interdependent tasks, value fit predicted only better citizenship behaviors, not higher performance.

Of course, the success of your practice will depend, in part, on the people you hire. Ritz-Carlton hotels use an elaborate system for assessing job candidates, and the qualities the company believes are crucial to its success. When Paul Hemp, a senior editor at the Harvard Business Review, spent a week at the hotel as a room-service waiter, he went through the new employee interview to see if he was the kind of candidate the Ritz was looking for. He said that “even after fudging my answers to a few questions, I got only ten points out of a possible fifteen in the composite hospitality assessment.” The interviewer told Hemp that a score of 10 was not bad, but they wanted someone with a score of 12. He later found that just taking care of his sister in a time of need was not an extraordinary example of caring, but if he had given her his house for a month, he would have earned a higher score. Using scientifically based criteria, the Ritz has managed to reduce its annual employee turnover from the industry average of 55 to 28%!

Surveys that rank the importance of pay is another area of interest for the endodontic practice. Research has shown that self-reports of pay significance are likely to “underestimate its importance due to norms
that view money as a somewhat crass source of motivation.” But money speaks, and getting the right combination of remuneration and benefits will positively impact your practice.

However, be certain to have any pre-employment exams or surveys thoroughly reviewed by an attorney or HR consultancy in order to ensure that it does not unintentionally skew results that disfavor applicants based on their protected EEO classes.

HIRING THE BEST PERSON FOR THE JOB

The hiring process should begin only after creating a set of job descriptions and an employee handbook. Once these documents are created, the next step is placing a job announcement in the print or online media or contracting with an employment agency. Typically, the Internet will produce same-day results and can be placed free of charge or on fee-based sites. An example of a job announcement for a Patient Coordinator written for Craig’s List, a popular online listing service follows:

Dental specialty office has immediate opening for a Patient Coordinator with a friendly attitude. If you share our vision of a customer-centered focus with a high-tech approach, this is the job for you! We are looking for someone who is a team player and enthusiastic (someone who likes to smile). You will need excellent telephone and customer service skills. Proficiency with MS Word and Excel is required. Responsibilities include answering the phones, scheduling, and welcoming new patients, billing, and organizing practice promotion activities.

This position requires some schedule flexibility as patient appointments may occasionally extend the workday. Our usual hours of operation are Monday to Friday 8:15 am until 5:15 pm. Employee handbook and complete benefits package including medical and parking await the right candidate. Please email your resume without attachments (cut and paste into body of email).

When candidates respond to the job announcement, a pre-interview screening of the applications by the person in charge of personnel can help in choosing the best qualified candidates. Ideally, the screener should review the applications for basic objective criteria and reject those that do not possess the minimum education, experience, or skills set. Having a formal intermediary step in the screening process may help insulate against litigation because it will interject an objectively neutral perspective into the hiring process that can mitigate any claims of bias.

It may also be helpful for you to conduct brief telephone interview with each of the remaining candidates. Asking a few open-ended questions like “Tell me about your recent job experience” may help to identify those applicants you deem worthy of further consideration and will provide an opportunity for the candidate to ask questions to determine whether they believe the job is right for them. After a positive phone conversation, invite the candidate for a face-to-face interview.

Have a job application form ready for the new candidate and make sure it includes appropriate language authorizing reference checks. Notifying the candidate of your intention to check references gives the candidate time to alert contacts to expect your inquiry. If you want to know what the prospective employee is really like, contacting his or her former employers may be the best way to find out. Many companies check references as the final part of their hiring process, and sometimes extend job offers with the condition that references check out. Using a reference request form with a waiver signed by the prospective hire is a good way to safely get the information. Try contacting former employers et al. at more than one company, if possible, to get the broadest picture of the candidate. It is best to restrict questions to those that relate to education, training, experience, qualifications, job performance, professional conduct, and reason for termination.

Check with your attorney or HR consultancy to make sure that you are in compliance with state employment laws. To ensure that the information exchanged is from a legitimate former employer, try using fax or mail to verify the information. To help make the process a little less litigious, many states have enacted legislation providing some immunity from civil liability for providing information about the employee. Also, many employers have their own policies regarding reference checks on current and former employees that restrict the information they divulge to position title and dates of employment. If you encounter such a response, do not automatically assume that the applicant had a negative employment experience with their previous employer.

The purpose of the initial interview is to form an impression of how the candidate will fit into the practice culture, confirm his or her technical skills, and narrow down the field of applicants. Keep a record of the conversation, with each question and answer documented for future reference. Always meet candidates at your office during regular business hours with other staff on premises during the entire meeting to preclude any chance of allegations of
inappropriate behavior. Unfortunately, many interviewers are improperly trained or uninterested in meeting with applicants. Nonetheless, endodontic practices, like other small businesses, need to adhere to good hiring practices or hire employees through employment agencies. Because many questions can open the door to non-job-related information that may be illegal, try to formulate behavioral questions guided by the job description. Having this list of questions ready will ensure that you get the precise information you need every time. Examples of good questions to ask are the following:

1. Tell me about a time when your teamwork with a co-worker helped you meet a patient’s needs.
2. Give me an example of a mistake you made while carrying out your job duties. What happened? How did you correct the mistake?
3. Tell me the procedures used for sterilizing a treatment setup.
4. What steps do you take to ensure patient and operator safety when working with a patient?

Asking the right questions allows you to control the interview and helps to make certain that the interview is legally compliant. It is important that you ask the same questions for each candidate during the hiring process to ensure that each applicant is treated equally.

Remember that there are areas where caution should be used in making pre-employment inquiries. Whether asked on an application form or in an interview, the EEO Commission and state Departments of Labor will consider some questions as evidence of discrimination, unless the employer is able to show that the inquiries are job-related or that there is a documented business-related necessity for asking the question. Partial list of subject areas to avoid during interviews:

1. Arrest records
2. Garnishment records
3. Marital status
4. Child-care provisions
5. Contraceptive practices
6. Pregnancy and future childbearing plans
7. Physical or mental disabilities
8. Age, height, and weight
9. Nationality, race, or ancestry
10. Other areas of potential discrimination include certain limiting physical requirements, availability for weekend work, appearance standards, and fluency of the English language.

Always avoid asking about the applicant’s immigration or citizenship status. Although it will be necessary for the applicant to establish that they are lawfully permitted work in the United States, questions regarding the specific immigration status of the applicant can give rise to national origin discrimination claims. It is permissible to ask the applicant the yes or no question “are you lawfully permitted to work in the United States?”

Interviewers should avoid any assurances related to job security. Assuring the interviewee that they will “have their job for as long as they do a good job” is fraught with risk. If the applicant accepts the job and 6 months later is laid off, a breach of contract claim could be filed, where the employee asserts that he or she cannot be terminated unless they did not do a good job.

Once an offer of employment has been extended and the candidate has accepted the offer, a welcome packet of office information should be presented. This packet can include a welcome letter, employee handbook, a listing of compensation and benefits, employee roster, hepatitis vaccination verification or declination form (if applicable), health insurance application, payment options, retirement plans (if applicable), and any other information deemed important for the new employee. In addition, federal and state withholding forms, along with the Department of Homeland Security, U.S. Citizenship and Immigration Services’ Employment Eligibility Verification form must be completed within 3 business days of the employment commencement date.

**POSTING OF EMPLOYEE NOTICES**

The US DOL and all states including the District of Columbia require that notices be provided to employees and/or posted in the workplace where employees can readily observe them. Designating a wall area in the employee locker room or break room will provide an ideal place for a bulletin board to post periodic notices to staff and federal and state posters. DOL provides free electronic and printed copies of these required notices and posters at the “elaws Poster Advisor” on the DOL Web site. State posting requirements can be determined by contacting your state DOL through the links page located on the DOL Web site. In addition, some states, like California, require distribution of pamphlets, such as the State Disability Insurance and Paid Family Leave pamphlets, to employees under certain circumstances.
EMPLOYEE BENEFIT AND SALARY ADMINISTRATION

Compliance with statutory wage and hour requirements is one of the areas that endodontic practices may find confusing, that is, hourly versus salaried compensation or complying with wage and hour requirements for staff travel to and attendance at continuing education meetings. Be sure to check with your HR advisors to determine the best policy.

Many practices use outside services for payroll processing and tax filing (i.e., W-2 and 1099 annual filing), reducing the chance of errors and incorrect filing of federal and state taxes. According to a recent study, the average small business that “ran payroll in-house and filed and paid quarterly taxes manually spent more than 250 hours away from customers... doing these tasks.”98 Offering direct deposit of wages to each employee’s own bank account is an additional way to improve security and encourage staff members to maintain individual privacy and avoid salary comparisons. Direct deposit has the added advantage of ensuring that wages are available to employees as quickly as possible. No one benefits by stressed-out staff members leaving the office during the business day to deposit their payroll checks. Check your state wage and hour laws to determine if you can require direct deposit before mandating this service. Some new endodontic practice management software even includes timesheets with biometric fingerprint identification technology.

Additional information is available from the American Dental Assistants Association, ADA, Dental Assisting National Board, Inc. and the DOL, Bureau of Labor Statistics, on the national estimates for dental assistant wages, including industry and metropolitan area profiles for this occupation (Table 5).

There are several important laws governing salary and benefits compensation packages. The Fair Labor Standards Act (FLSA), the Employee Retirement Income Security Act (ERISA), and the (HIPAA) impose a myriad of complicated rules and regulations governing retirement plans, health insurance, cafeteria plans, and other benefits of employment. It is important that you seek guidance from a plan benefits advisor and attorney or HR consultant in deciding how to structure your employee salary and benefits packages.

TERMINATION

Few practice owners or managers want to face the emotionally charged process of firing people. Terminating employees in a way that preserves their dignity while preventing costly mistakes will benefit both the employee and the practice. The actual termination process will stay in everyone’s mind for a long time and speak volumes about the practice. At best, a successful termination can make the employee a friend of the practice and in the worst scenario can result in a costly legal process. A termination will also affect co-workers if not handled properly, even if the employee is not well liked. Remember that in most jurisdictions, employees have the right to claim unemployment benefits which will often raise the practice’s tax rate. The burden of proof is almost always on the practice to prove the reason for the separation in unemployment claims cases.

Even after carefully vetting new employees, he or she may not meet your expectations or may even act illegally. As soon as performance or discipline problems become apparent, start documenting your communications with the employee in question. Before terminating an employee, review your

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<tr>
<td>Employment RSE</td>
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<td>Percentile wage estimates for this occupation</td>
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<td>Hourly Wage</td>
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employment offer letters, company policies, handbooks, and performance reviews to assure compliance with the practice’s policies. If an employee performance review was conducted, exercising special care will help reduce the chances of litigation in the following situations: (1) when firing someone who has filed prior complaints about harassment or Occupational Safety and Health Act (OSHA) violations; (2) is older than 40 and covered by the Age Discrimination in Employment Act (ADEA); (3) is a member of a minority group because of race, color, gender, religion, or national origin; (4) has an employment contract; (5) has been promised job security or long tenure; and (6) if you are laying off more than one employee at once. In all cases, every employee must be treated even-handedly.

In determining whether to discipline or terminate an employee, it may be helpful to consider various factors to preserve objectivity. Consider the following:

1. The nature and seriousness of the offense and its relation to the employee’s duties, position, and responsibilities, including whether the offense was intentional, technical, inadvertent, malicious, for personal gain, or was frequently repeated.
2. The employee’s job level and type of employment, including supervisory or fiduciary role and contacts with customers.
3. The employee’s past disciplinary record.
4. The employee’s past work record, including length of service, performance on the job, ability to get along with fellow workers, and dependability.
5. The effect of the offense upon the employee’s ability to perform at a satisfactory level and its effect upon supervisors’ confidence in the employee’s work ability to perform assigned duties.
6. Consistency of the penalty with those imposed upon other employees for the same or similar offenses.
7. The notoriety of the offense or its impact upon the reputation of the practice.
8. The clarity with which the employee was on notice of any rules that were violated in committing the offense or had been warned about the conduct in question.
9. The potential for the employee’s rehabilitation.
10. Mitigating circumstances surrounding the offense such as unusual job tensions, personality problems, mental impairment, harassment, or bad faith, malice or provocation on the part of others involved in the matter.
11. The adequacy and effectiveness of alternative sanctions to deter such conduct in the future by the employee or others.

Although this list is not complete, it is a good starting point to consider when dealing with employee misconduct.

In sensitive firing situations or if terminating an employee is new to you, consult with an experienced employment lawyer or labor advisor ahead of time to prepare what to say, understand state laws that govern termination, and have all paperwork, salary checks, and severance pay ready to give to the employee. Always keep all discussions confidential and document the termination to aid in future communications with any state or federal agencies. Be prepared to answer the employee’s questions about their schedule, severance pay, references, what will co-workers be told, medical and other insurance benefits, keys and security cards, profit sharing plan, if any, and eligibility for unemployment insurance.

Conducting an exit interview is another way to improve the work environment for the practice. Exit interviews should be conducted separately from the termination meeting and in small practices can be a simple survey to be mailed back or a phone conversation. Explain that the purpose of the interview is to gather information about the employee’s experience at the practice and how it treats employees. Be sure to set the right tone, stay objective, and listen without providing opinions or becoming defensive.

**EMPLOYMENT LAW**

Many dentists assume that as they are practicing in an “at-will” state, they can discharge employees at any-time without problems. In certain circumstances, other issues can supersede the “at-will” prerogative, like violating an employee’s civil rights. For example, the practice cannot discriminate against an employee who belongs to a protected class, where issues regarding age, sex, race, color, religion, disability, or national origin may play a role. Get the advice of legal counsel or your HR advisory firm if you plan to discharge an employee whose dismissal may trigger other issues.

It is best to administer your employment practices in a fair, equal, and consistent manner by counseling and documenting disciplinary and performance problems in written form. Include specific comments (i.e., reason for counseling, nature of disciplinary action, corrective action expected, consequences of non-compliance, and employee and employer comments) that are dated and signed by the administrator, employee, and a neutral witness, if possible. Never include an employee’s co-workers or peers in the termination process.99
The following suggestions may help avoid common legal pitfalls:

1. Maintain two types of personnel files for each employee, regular and confidential. The I-9 form should be kept in the confidential file and should not be given to anyone for inspection without legal advice. The I-9 form should be kept for 3 years from date of hire or 1 year from termination, whichever is longer.

2. Have an established protocol to follow when an employee or former employee or their attorney asks to review his or her personnel file.

3. Have a signed employment handbook with each employee.

4. Prohibiting employees from talking about their wages or benefits is not allowed under the National Labor Relations Act which specifies the right of employees at all workplaces, unionized or not, to engage in collective bargaining.

5. To protect the privacy of employees, keep all employee files locked or off-site. Records in many states can only be disposed of by destruction, modification, or other reasonable action to protect personal information.

6. Employee records must be maintained on the following schedule. OSHA: OSHA requires that records of job-related injuries and illnesses be kept for 5 years. Employers are also required to fill out and post an annual summary. Any exposure to toxic substances and blood-borne pathogens along with any records related to medical exams must be retained for 30 years after termination of employment. FLSA: Under the FLSA, the record-keeping requirements are 3 years to cover both supplementary basic records and payroll records. Civil Rights Act of 1964, Title VII, ADEA and the Americans with Disabilities Act (AwDA): Under the Civil Rights Act of 1964, Title VII, and the AwDA, employers with at least 15 employees must retain applications and other personnel records relating to hires, rehires, tests used in employment, promotion, transfers, demotions, selection for training, layoff, recall, terminations of discharge, for 1 year from making the record or taking the personnel action. The ADEA requires the retention of the same records for 1 year for employers with 20 or more employees. Title VII and the AwDA require that basic employee demographic data, pay rates, and weekly compensation records be retained for at least 1 year.

7. Family and Medical Leave Act (FMLA): The FMLA requires the retention of certain records for 3 years with respect to payroll and demographic information as well as information related to the individual employee’s leave of absence.

8. IRS: IRS rules require keeping copies of employment tax records (Social Security documents) for 4 years after the due date of the tax. If a claimant files a claim, the retention period should extend for 4 years after the date of the filing. (26 CFR 31.6001).

Other employment law issues to be aware of include the following:

1. The Uniformed Services Employment and Reemployment Rights Act (USERRA): USERRA requires employers to hold available the position of employees who are active reservists called for duty. This includes short-term assignments for training which may only require a few days of leave, or long-term active duty in times of conflict. Additional guidance may be found at the DOL Web site at http://www.dol.gov/elaws/userra.htm.

2. The Pregnancy Discrimination Act: An amendment to Title VII of the Civil Rights Act of 1964, the Pregnancy Discrimination Act prohibits an employer from treating an employee who becomes pregnant differently than any other employee with a serious medical condition. For example, if your practice grants extended leave (either paid or unpaid) to an employee recovering from a heart attack, you must grant the same consideration to a pregnant employee. Keep in mind, that pregnant employees may also have additional rights under the Family Medical Leave Act.

3. Sexual Harassment: It is imperative that your practice have a strongly worded written policy stating that sexual harassment will not be tolerated. It should include a provision that employees who report sexual harassment will not be retaliated against and notify them of a confidential process for reporting any instances of harassment. You should take prompt and remedial action in addressing any allegations of harassment including investigating the claims, separating the person who reported the harassment from the alleged harasser, and taking any necessary disciplinary actions. For more information, please refer to the U.S. Equal Employment Opportunities Commission (EEOC) guidance at http://www.eeoc.gov/policy/docs/harassment.html.

4. Local Laws: Local laws may expand or modify Federal employment statues, so it is necessary that
you consult with an attorney or HR consultancy to become aware of any additional requirements. For example, some jurisdictions also prohibit discrimination on the bases of sexual orientation and/or political affiliation.

CONFIDENTIALITY AND NON-COMPETITION COVENANTS
Some employers require employees to sign non-compete covenants and confidentiality clauses. Generally, non-competition covenants with administrative or clerical staff will be held invalid. Some firms may legitimately enter into non-competition clauses with associates or other professional staff within their practice so long as they are for a limited duration (1 or 2 years); not overly restrictive (limited to a specialty practice and not the entire medical or dental profession); and of a limited geographic scope (a few mile radius of the current practice location). Keep in mind state laws and professional ethics rules may bar any non-compete covenants.

Contrary to covenants not to compete, confidentiality clauses can be enforced so long as they pertain to proprietary procedures or information and patient medical information. Consult with an attorney if you are considering either covenant.

EMPLOYMENT LIABILITY PRACTICES INSURANCE
Liability arising from employment practices continues an upward trend that shows no signs of abating. Unlike comprehensive general liability (CGL) policies, which insure against claims for tangible damages, for example, property damage, employment practices liability insurance (EPLI) insures against claims arising from employment practices. CGL policies differ from EPLI policies by excluding intentional acts and bodily injury that might occur while working. Also, CGL policies cover claims made while the policy is in effect, even if the claim is brought years later, whereas EPLI will cover only claims made during the coverage period or claims that the employer knew about or should have known about during the coverage period.

Many EPLI policies include wording that requires the insurance carrier to defend the employer against claims, even if the deductible has not been met. However, these clauses allow the carrier to choose the attorney who will defend the employer against the claim. Some policies also contain a provision that allows the carrier to settle the case, and if the employer rejects the settlement offer, the carrier can limit its liability to the amount offered in settlement or require arbitration. Before purchasing coverage, carefully review limitations and exclusions to make sure the policy fits your needs, as follows: (1) find out what is covered in addition to wrongful termination, harassment, and discrimination, such as invasion of privacy, negligent supervision, and hiring issues; (2) check to see if the policy will cover claims made by current part-time or temporary employees, independent contractors, and the EEOC; (3) confirm that you can choose your legal defense team; and (4) choose a carrier that has a solid track record in the field.

WORKERS’ COMPENSATION
Workers’ compensation provides wage replacement benefits, medical treatment, vocational rehabilitation, and other benefits to certain workers or their dependents that experience work-related injury or an occupationally related disease. Workers’ compensation claims can be minimized by ensuring a safe workplace and making sure employees are capable of performing their jobs before they are hired. Employers cannot ask about a prospective employee’s Workers’ compensation history before a job offer is made.

Whenever a work-related injury occurs, make sure that an accident report is completed and a notification is provided to your Workers’ compensation insurance provider. Any work-related injury that occurs over a period of time, like carpal tunnel syndrome or hearing loss, must be reported by the employee as soon as he or she learns that it is work-related.

STAFF MEETINGS AND PEAK PERFORMANCE
As the U.S. demographic picture continues to change, and the population/dentist ratio exacerbates healthcare manpower shortages, especially in rural and underserved areas, there has never been a greater need for the dental team to work more efficiently. Dental practices must not only “provide optimum patient care, but also must operate as a profit-making business” to ensure the ability to upgrade facilities and acquire new technologies and training.

Along with hiring the right people, using meetings to enhance peak performance and improve service quality are the hallmarks of a well run office. The “morning huddle,” a 10- to 15-minute briefing, facilitated by the patient coordinator, is a valuable way to keep up-to-date on patients, procedures, scheduling, upcoming events, and miscellaneous matters. As a group, determining the best place to schedule emergency patients and share suggestions about how to fill
Appointment openings will improve efficiency and reduce stress. The agenda should include a brief review of production and collections from the previous day, expected for the current day, and the month, along with some time to discuss operational issues that need attention. Try to end on a positive note, adding a birthday or anniversary acknowledgement, a joke or a complement.102

Regular staff meetings are another way that practices stay ahead. Start by creating a file for staff to place suggestions and complaints between meetings (a word processing file accessible to all computers on the network will be helpful). Make the meetings a safe environment for all to be heard, take minutes, and create a written action plan that gets reviewed in 48 hours to measure progress.103 Hotel chains like the Ritz-Carlton, home of legendary customer service excellence and two-time winner of the Malcolm Baldrige Award, have pioneered many innovations in customer service. Believing that employees are one of the keys to success, the Ritz-Carlton hotels “win the hearts and minds of its employees by making them feel part of a proud heritage.”104 Success in dental practice, and any profession for that matter, involves the construction of organizational processes and capabilities necessary to achieve performance through people delivering results and process quality.

Lastly, and all too often, organizations reach their goals and start planning new initiatives while forgetting to celebrate their accomplishments. Take time to acknowledge practice accomplishments by scheduling events, sending letters of praise, and giving out bonuses that say “Thank You!”

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Disclaimer: The information in this chapter should not be construed as legal advice or a standard of care. Readers should not act upon any information unless they consult with an attorney as management advice must be tailored to the specific circumstances of each case. Nothing provided herein should be used as a substitute for individual endodontic or dental management advice. Laws vary considerably from jurisdiction to jurisdiction, and even within jurisdictions. Therefore, some information may not be correct for a jurisdiction or locale.

References

52. Hotels. When two or three or four names are better than one. Hotels 2004;38:20–20.
60. Harris Interactive. Number of “cyberchondriacs” – U.S. adults who go online for health information – increases to estimated


102. Ousborne AL. Morning meetings that matter. Dent Econ 2003;34:34.

103. Rose, KA. Personal communication, Jan 8, 2007.


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