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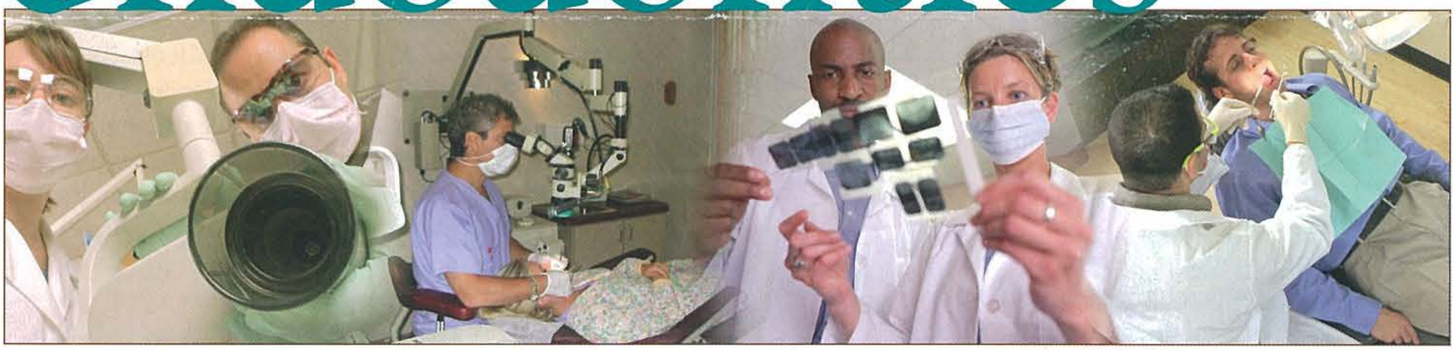

The Effect of New Obturating Materials on Vertical Root Fracture of Endodontically Treated Teeth

A serious complication after root-canal therapy is vertical root fracture, which extends throughout the entire thickness of dentine and cementum from the canal space to the periodontium. Vertical root fracture is a serious clinical concern with a poor prognosis, usually resulting in extraction of the tooth or resection of the affected root.

Since few materials have seriously challenged gutta-percha and sealer in the majority of endodontic situations, researchers continue to look for alternatives that may seal better and mechanically reinforce compromised roots. Hammad et al from the University of Manchester, United Kingdom, evaluated in vitro the effect of different combinations of root-filling materials and sealers on vertical forces at fracture of endodontically treated teeth. The null hypothesis was that there are no differences between materials in vertical-fracture resistance.

A total of 67 single-rooted extracted teeth were divided into 5 groups. Group 1 included the negative controls (uninstrumented canals). The remaining 4 groups were shaped to a final size of F3 using ProTaper rotary files (Dentsply Maillefer, Ballaigues, Switzerland). Group 2 included canals obturated with gutta-percha and a zinc oxide sealer; group 3, canals obturated with EndoRez points and EndoRez sealer (Ultradent, South Jordan, Utah); group 4, canals obturated with Resilon (Pentron Clinical Technologies, Wallingford, Conn.); and group 5, canals obturated with GuttaFlow (Colténe/Whaledent, Altstätten, Switzerland). The roots were then fixed into a universal testing machine and loaded with a spreader until fracture occurred.

The mean force to fracture of the control group was higher than that of any other group (Table 1). Resin-based

EndoRez and Resilon had a mean force to fracture higher than the gutta-percha and GuttaFlow groups but lower than the control group. There was no statistically significant difference in the mean force at fracture between Resilon and EndoRez or between gutta-percha and GuttaFlow.

Gutta-percha did not show increased resistance to internally generated stresses in the root canal because it exhibited lower mean forces to fracture when compared with Resilon and EndoRez. GuttaFlow also did not show increased resistance to internally generated stresses.

Conclusion

These findings were not surprising because both gutta-percha and GuttaFlow do not chemically bond to the dentine wall, so they do not form the monoblock system. The results suggest that Resilon and EndoRez both increased the fracture resistance of endodontically treated roots to internally generated stresses. Therefore, a resin-based root filling material may be considered when root strengthening would benefit the clinical situation.

Hammad M, Qualtrough A, Silikas N. Effect of new obturating materials on vertical root fracture resistance of endodontically treated teeth. J Endod 2007;33:732-736.

Table 1. *Mean force in newtons (N) for vertical root fracture*

Group	Mean force (N)	SD	Maximum force (N)	Minimum force (N)
Control ($n = 10$)	245.26*	41.29	295.0	221.0
Gutta-percha ($n = 13$)	90.15	13.92	105.1	68.0
Resilon ($n = 13$)	146.31†	49.64	249.0	104.0
EndoRez ($n = 13$)	169.40†	47.02	241.0	112.0
GuttaFlow ($n = 12$)	74.06	28.70	130.0	44.5

**Significantly different from all other groups ($p < .05$); †significantly different from gutta-percha and GuttaFlow groups ($p < .05$).*

A Chlorhexidine-Based Protocol for Bacteria Reduction

Successful endodontic treatment of teeth with apical periodontitis depends on the effective elimination of the root-canal infection. Traditional methods involve the use of sodium hypochlorite (NaOCl) as an irrigant and often calcium hydroxide ($Ca[OH]_2$) as an intracanal medication. Although these methods have been shown to be effective in eliminating bacteria from infected canals, they have limitations.

Chlorhexidine (CHX) is a widely used antimicrobial agent that has emerged as an effective endodontic irrigant and interappointment medicament. As an irrigant, CHX has demonstrated antimicrobial effectiveness comparable to NaOCl. Whereas CHX lacks tissue-dissolving ability (one of the benefits of NaOCl), it also has some advantages over NaOCl. CHX has been reported to be less toxic to host tissues and has substantivity to dentin, which may result in residual antimicrobial effects for days to weeks. As an intracanal medication, CHX can be used alone or combined with $Ca(OH)_2$ in a paste.

$Ca(OH)_2$ is the most commonly used intracanal medication, but it does not kill all species of endodontic flora; therefore, it has been recommended that other antimicrobials be added to $Ca(OH)_2$ in order to enhance its effectiveness. Supplementing the antimicrobial activity of $Ca(OH)_2$ with CHX has been extensively studied in vitro. Several studies have shown that the antimicrobial effects of $Ca(OH)_2$ are significantly increased when adding CHX, while other studies have been less positive. Siqueira et al from Estácio de Sá University, Brazil, conducted a clinical study to assess the bacterial reduction after instrumentation using 0.12% CHX digluconate solution as an irrigant and the additive antibacterial effect of intracanal dressing with $Ca(OH)_2$ mixed with 0.12% CHX digluconate gel.

According to stringent inclusion/exclusion criteria, 13 teeth with primary intraradicular infections and chronic apical periodontitis were selected. Bacterial samples were taken before treatment (S1), after instrumentation using CHX as an irrigant (S2) and then after a 7-day dressing with $Ca(OH)_2$/CHX paste (S3). Cultivable bacteria recovered from infected root canals at the 3 stages were counted and identified by molecular sequencing.

At S1, all canals were positive for bacteria; after S2, 53.8% of canals still harbored bacteria; and after S3, only 1 canal (7.7%) was positive for bacteria. There was a significantly high reduction in bacterial counts between S1 and S2, and S1 and S3. There were also significant differences between S2 and S3 with regard to both quantitative bacterial reduction and number of cases yielding negative cultures.

Conclusion

Root-canal instrumentation and irrigation with 0.12% CHX solution significantly reduced the number of intracanal bacteria but failed to render the canal bacteria-free in about half of the cases. Application of a 7-day intracanal dressing with $Ca(OH)_2$/CHX paste further increased the percentage of cases yielding negative cultures to 92.3%. Therefore, it appears that for a more predictable antimicrobial effect, CHX should be used as part of the irrigation routine. Also, the application of an interappointment antimicrobial dressing should be considered for teeth that have periapical disease.

Siqueira JF Jr, Paiva SSM, Rôças IN. Reduction in the cultivable bacterial populations in infected root canals by a chlorhexidine-based antimicrobial protocol. J Endod 2007;*33*:541-547.

C-shaped Root-canal Anatomy

A unique anatomic variation in human teeth is the "C" configuration (Figure 1), named for its cross-sectional morphology of the root and root-canal system. Apical to the orifice level, the root structure can harbor a wide range of anatomic variations. These can be classified into 2 basic groups: those with a single, ribbon-like, C-shaped canal from orifice to apex and those with several distinct canals below the C-shaped orifice.

Once recognized, the C-shaped canal creates a challenge with respect to instrumentation and obturation, especially because it is unclear whether the C-shaped orifice found on the floor of the pulp chamber actually continues to the apical foramen. Typically, this canal configuration is found in teeth with fused roots. The main anatomic feature of C-shaped canals is the presence of anastomoses connecting the individual canals.

Cheung et al from the University of Hong Kong investigated the anatomy of C-shaped canals in mandibular molars. Forty-four permanent mandibular second molars with C-shaped root-canal systems were scanned by microcomputerized tomography. The apical half of each root was 3-dimensionally (3D) reconstructed for visualization and classification.

The authors found that the majority of these C-shaped canals possessed 2 or 3 main root canals. Twenty percent of these teeth had ≥4 main canals; approximately 36% had 2 main apical foramina, 1 in each fused root; and about 16% possessed a single canal and a single main foramen. Accessory and lateral canals, canal anastomoses and apical deltas were noted on the 3D-reconstructed models. The prevalence of these anatomic features ranged from 11–41%.

A C-shaped canal can lead to difficulties during treatment, so proper diagnosis is essential. A straight-on preoperative radiograph as well as additional angulated radiographs often provide clues about the canal morphology. Common radiographic characteristics of this entity are fused and conically shaped roots, a large distal canal, a narrow mesial canal and a blurred image of a third canal in-between. Radiographs taken while negotiating the canals may reveal 2 characteristics for such canal configuration: instruments tend to converge at the apex and/or may exit at the furcation. The latter sometimes may resemble a perforation.

Figure 1. Endodontic access cavity demonstrating C-shaped configuration. (Photo courtesy of Dr. John Khademi.)

Clinical recognition of C-shaped canals is based on the anatomy of the floor of the pulp chamber; however, the chamber can be calcified and/or the floor may be covered with pulp stones, disguising its C shape. At the outset, several orifices may be probed that connect on further instrumentation. Clinically, when a C-shaped canal orifice is observed under the operating microscope, it cannot be assumed that such a shape continues throughout its length, though the increased magnification and illumination provided by the use of microscopes has made treatment more predictable.

Deep-orifice preparation and careful exploration with small files are necessary for C-shaped root-canal treatment. In all categories, the mesiobuccal and distal canal spaces can usually be prepared somewhat normally; however, isthmuses should not be prepared with large files (especially large taper), as a strip perforation is possible. In addition, Gates-Glidden burs should never be used to prepare isthmus areas. Adjunctive canal-cleaning techniques, such as the use of ultrasonics, appear to be more effective. Although ultrasonic preparation may effectively remove tissues from narrow C-shaped canal ramifications, aggressive instrumentation may cause perforation.

Conclusion

The apical anatomy of C-shaped root-canal systems in mandibular second molars is extremely complex, with many anatomic variations. Special care must be taken when treating these teeth because the risk of complications during treatment is high.

Cheung GSP, Yang J, Fan B. Morphometric study of the apical anatomy of C-shaped root canal systems in mandibular second molars. Int Endod J *2007;40:239-246.*

Regenerative Endodontics

Regenerative endodontics is defined as biologically based procedures for replacing damaged dentin and root structures, as well as cells of the pulp-dentin complex. Regenerative dental procedures date to around 1952, when Hermann reported on the application of calcium hydroxide in a vital pulp amputation. Subsequent regenerative dental procedures include the development of guided tissue regeneration and guided bone regeneration procedures and distraction osteogenesis; the application of platelet-rich plasma for bone augmentation, Emdogain for periodontal tissue regeneration, and recombinant human bone morphogenic protein for bone augmentation; and preclinical trials on the use of fibroblast growth factor 2 for periodontal tissue regeneration.

Despite these applications and the development of certain medical tissue regeneration procedures (e.g., bone marrow transplants), there has not been a significant application of any of these therapies into clinical endodontic practice. Murray et al from Nova Southeastern University, Florida, reviewed the literature to provide an overview of regenerative endodontics and to encourage the development of these therapies for regular clinical practice.

The objectives of regenerative endodontics are to regenerate pulp-like tissue: ideally, the pulp-dentin complex; damaged coronal dentin (e.g., caused by a carious exposure); and resorbed root structure. Several major areas of research that may have application in the development of regenerative endodontic techniques are

1 Root-canal revascularization via blood clotting;

2 Postnatal stem-cell therapy;

3 Pulp implantation;

4 Scaffold implantation;

5 Three-dimensional cell printing; and

6 Gene delivery.

These regenerative endodontic techniques include specific consideration of cells, growth factors and scaffolds.

The clinical success rate of endodontic treatments can exceed 90%; however, many teeth that might have been saved by endodontic treatment are extracted instead, with subsequent placement of an artificial prosthesis, such as an implant. Since regenerative endodontic methods have the potential to regenerate both pulp and dentin tissues, they may offer an alternative method for saving teeth with compromised structural integrity.

Each regenerative technique (either hypothetic or at an early stage of development) will have advantages and disadvantages. For regenerative endodontic procedures to become widely available, endodontists will have to depend on tissue-engineering therapies to regenerate pulp and dentin tissues. The proposed therapies involving stem cells, growth factors and tissue engineering all require pulp revascularization, which is in itself an enormous challenge.

One of the most challenging aspects of developing regenerative endodontic therapies is understanding how to optimize the various component procedures and integrate them to produce a regenerated pulp-dentin complex. The development of these procedures will require a comprehensive research program.

Conclusion

The authors believe that regenerative endodontics is an inevitable therapy, and they call for the resources to hasten its development. The potential of regenerative endodontics may ultimately benefit millions of patients each year.

Murray PE, Garcia-Godoy F, Hargreaves KM. Regenerative endodontics: a review of current status and a call for action. J Endod *2007;33:377-390.*

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