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Grado en Odontología

New trends in designing access cavity in Endodontics.

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Abstract

Objectives: This present study was designed to introduce the evolution of access cavity in endodontics and summarize the previous studies. Furthermore, it evaluated the indication of different type of access cavity by comparing the previous studies.

Methodology: Only the studies regarding conservative endodontic access cavity from 2010 to 2020 were included. The exclusion criteria for the studies were publication year before 2010 or collected sample less than 30 teeth. Finally, 15 studies were selected through Pubmed.

Results: Conservative endodontic cavity benefits the preservation of dentin; however, there are more studies stated that conservative endodontic cavity has no positive impact on fracture strength of the tooth. Besides, Conservative endodontic cavity might compromise the detection of extra canals and complicate the manipultaion of instumentation and obturation. Further studies are required due to the drawbacks and limitations of previous studies.

Conclusion: Within the limitations of the studies so far, no positive impacts have been found utilizing Conservative endodontic cavity in incisors, and there are no clear benefits using Conservative endodontic cavities in all respects. In addition, considering that most of the studies found no positive impacts regarding fracture resistance of Conservative endodontic cavities and given the complicated manipulation of Conservative endodontic cavities. Nowadays, the use of traditional endodontic cavity in daily practice is sufficient to solve most of the cases. There is a lack of supporting evidence to promote conservative endodontic cavities in clinical practice and no adequate reasons to develop the training of this technique in dental clinicians. In short, the use of conservative endodontic cavities is not necessary in all type of teeth until the further randomized controlled trials existed in the future.

Key words: traditional endodontic cavity, contracted endodontic cavities, ninja, truss, fracture resistance, instrumentation efficacy, transportation.

Resumen

Objetivos: El presente estudio fue diseñado para presentar la evolución de la cavidad de acceso en endodoncia y resumir los estudios previos. Además, evaluó la indicación de diferentes tipos de cavidad de acceso comparando los estudios anteriores.

Metodología: Solo se incluyeron los estudios sobre la cavidad de acceso endodóntico conservador de 2010 a 2020. Los criterios de exclusión para los estudios fueron el año de publicación antes de 2010 o la muestra recolectada de menos de 30 dientes. Finalmente, se seleccionaron 15 estudios a través de Pubmed.

Resultados: La cavidad de acceso endodóntico conservador beneficia la preservación de la dentina; sin embargo, hay más estudios afirmaron que la cavidad endodóntica conservadora no tiene un impacto positivo en la resistencia a la fractura del diente. Además, la cavidad endodóntica conservadora podría comprometer la detección de canales adicionales y complicar la manipulación de la instumentación y obturación. Se requieren más estudios debido a los desventajas y limitaciones de los estudios anteriores.

Conclusión: Según los estudios hasta ahora, no se han encontrado impactos positivos utilizando la cavidad endodóntica conservadora en los incisivos, y no hay beneficios claros con la utilización de las cavidades endodónticas conservadoras en todos los aspectos. Además, considerando que la mayoría de los estudios no encontraron impactos positivos con respecto a la resistencia a la fractura de las cavidades endodónticas conservadoras y dada la complicada manipulación de las cavidades endodónticas conservadoras. Hoy en día, el uso de la cavidad endodóntica tradicional en la práctica diaria es suficiente para solucionar la mayoría de los casos. Existe una falta de evidencia de apoyo para promover las caries endodónticas conservadoras en la práctica clínica y no hay razones adecuadas para desarrollar la formación de esta técnica en los odontólogos. En resumen, el uso de cavidad endodóntica conservadora no es necesario en todo tipo de dientes hasta que existan más ensayos controlados aleatorios en el futuro.

Palabras clave: cavidad endodóntica tradicional, cavidade endodóntica conservadora, ninja, truss, resistencia a la fractura, eficacia de la instrumentación.

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Introduction:

Historically, endodontically treated teeth are more breakable and have a higher possibility of fracture compared with vital teeth(1–3). A large number of risk factors are involved, including quantity of the substance loss, dehydration of dentine after treatment, different filling technique, post selection(1,4,5). Preparation of access cavity is the most challenging and a vital step in endodontic treatment.

Design of access cavity would affect the quantity of the substance loss, since the 1980s, the concept of “complete unroofing of the pulp chamber and straight-line access to the level of the mid-root canal curvature” has been promoted, which nowadays called the “traditional endodontic cavity” (TEC) (6). Its principles include:

- The removal of all carious dentin and defective restorations(7)(8).
- The outline form(7,8).
- The convenience form(7,8).
- The “toilet” cleaning of the cavity.
- The extension for prevention (7).

In traditional endodontic cavity preparation, the initial penetration should be on the center of the pulp chamber(8). Outline form can be considered as a projection of the internal anatomy to the external surface. There are three factors determine the outline form: size of pulp chamber, shape of pulp chamber, number and direction of root canal. Then, achieving a straight line access from occlusal surface to the apical foramen is the main objective of convenience form to improve visibility and following instrumentation(9). The toilet cleaning of the cavity pointed out that to avoid obstruction of the root canal, removing debris and necrotic substance by irrigation is crucial and indispensable. The extension for prevention is accomplished by sacrificing additional tooth structure to prevent iatrogenic complications(8).

The traditional access cavity provided some benefits, such as the improved visibility, the better management during cleaning, shaping, and obturation procedures, the enhanced exploration of the canal openings(7,10). It remained dominant and has been unchanged for decades. Nevertheless, a concern regarding TEC is the excessive removal of the sound tooth structure might lead to future fracture or deformability of the tooth(8,11).

In order to avoid it, the endodontic access cavity design has been modified first by Clark and Khademi to minimize the tooth structure removal and this nowadays was known as the Conservative Endodontic access Cavity (CEC), which emphasizes

• Partial deroofing of the pulp chamber(6).

• Conservation of the maximum amount of peri-cervical dentin in posterior teeth

•Preservation of the peri-cingulum dentin in anterior teeth.

•Formation of soffit(7,12,13).

Conservative Endodontic access Cavity overlooks the concept of straight-line access and complete unroofing of the pulp chamber and aims to be least invasive and preserve the tooth structure as much as possible(6,14). Peri-cervical dentin is the dentin located 4 mm above and 4 mm below the CEJ(15–17). It is mainly responsible for distribution of the occlusal force to the root; hence, it is major contributing factor in improving fracture strength of the tooth and it is irreplaceable by any other material(13). In anterior teeth, there is an area called peri-cingulum dentin. The forces are concentrated at the cingulum when the upper front teeth are burdened in mastication; therefore, it acts as a cushion and it is crucial for the strength of the tooth(13,18). Soffit is a little segment of pulpal roof encircling the total coronal portion of the pulp chamber(13). If it is removed, the surrounding peri-cervical dentin may be damaged(12); in addition, the main reason to preserve soffit is to avoid gouging of the lateral walls(13).

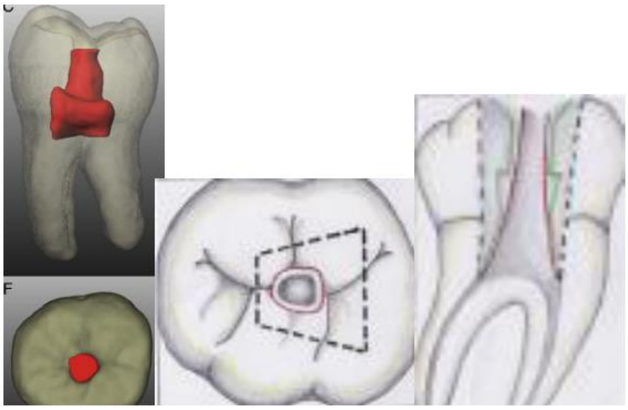
Conservation of the pulp horns and slightly convergent walls occlusally beveled is one of the keys of CEC, so that the floor of pulp chamber and the orifices of the root canal are viewed from different angulation(7,19,20). While performing a conservative access cavity, the opening should be as conservative as possible without a predetermined shape from the beginning, until it is necessary to enlarge the cavity to achieve a better visibility (7).

As time goes by, these principles have been interpreted by creating different access cavities(12). For instance: Truss access, Ninja Endodontic Access Cavity, Caries leveraged access, Calla Lily Enamel Preparation, Guided endodontic access, Dynamic Guided access(12).

Truss access consists of separate cavities directed to each canal orifice, rather than removing whole pulp chamber roof. The principle of this access cavity is to preserve the dentin in between the cavities which strengthening the remaining tooth structure(21). More specifically, in case of a premolar, we could prepare the buccal and palatal canal separately by preparing two openings in buccal and palatal parts of the occlusal surface leaving an intact tooth structure between the two openings. In case of a mandibular molar, the mesiobuccal canal and the mesiolingual canal could be prepared in a single opening, and the distobuccal canal and the distolingual canal could be prepared in the other opening, therefore, the intact tooth structure in between can reinforce the strength of the walls. Nevertheless, the drawbacks of truss access include time consuming, compromising the debridement efficiency, and inaccuracy which may lead to gouging, perforation, more instrument breakage(6).

Truss access cavity (13)

The objective of ninja cavity is to perform a small hole on the occlusal surface and all of the canal orifice can be localized successfully (22). It usually starts from the central fossa, then conically towards the canal orifices(22)(23). In the case of anterior teeth, if attrition or a deep concavity is presented in the lingual surface of the crown, the access can be carried out in the middle of the incisal edge, and parallel to the long axis of the tooth. (19)(24)

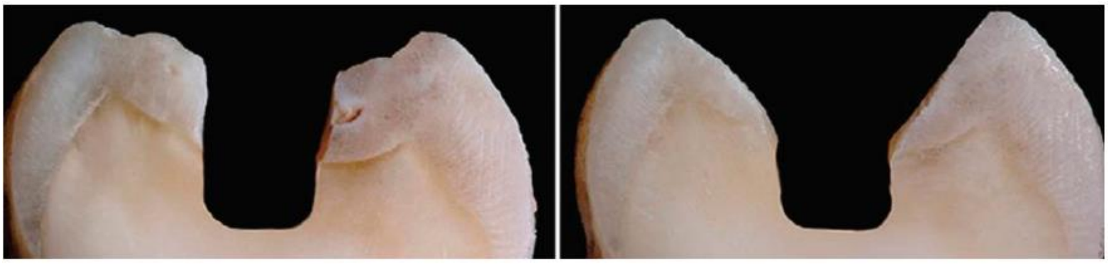


Ninja access cavity(13)

In caries leveraged access, tooth structures of no value or low value including tertiary dentin, undermined enamel, caries, and restorations can be used as a starting point and be removed for access preparation. Direct conservation of healthy dentin and removal of discontinuities in tooth structure can be achieved in this access design.(12)

Caries leveraged access cavity in lower first molar(12)

In Cala Lilly preparation, shape of the access appears like calla lily flower. In this preparation a bevel (45 degree) is made on the enamel portion of access cavity to remove undermined enamel. The majority of occlusal surface is involved, therefore, it improves the resistance and strength of the access preparation (12).



Cala lilly preparation(13)

In “Guided Endodontics” method, 3D printing technique is used to achieve minimal invasive access to root canals. Intraoral scanning is done followed by CBCT scanning. Virtual drill path is then planned on the computer screen which is designed by combining the data from intraoral scanning and CBCT and virtual sleeve is made for the guiding of the bur(13). The template is printed with 3D printer and attached to model. Then the preparation is made with specifically designed bur(12).

Dynamic guidance was proposed by Dr. Maupin as a solution for the difficulties in the use of static drill guides in guided endodontics(25). It uses an overhead three dimensional camera system (X-NAV System) which helps to immediately present the position of the patient’s jaw and the bur in 3D during the clinical procedure (12). It has significant advantages over guided endodontic access which lacks inter-occlusal distance and needs waiting time for the preparation of a 3D printed guide (25).

Broadly speaking, CECs avoid the excessive invasiveness of tooth structure and enhance the fracture resistance; however, some concerns may be identified, it might

• Compromise the efficacy of root canal instrumentation in lower molars(11)(26).

• Increase the possibility of mishaps of root canal, such as transportation, perforation, and ledging of the canals(6).

• Make subsequent obturation of root canal and coronal restoration more complicated.

• Require longer instrumentation time

So far, there is no randomized controlled trials to support that Conservative Endodontic access Cavities participate in the durability and lifespan of the teeth(7). Furthermore, there are studies suggesting that CECs don’t have a positive effect regarding fracture strength of the tooth(14,27). Given the doubt existed and the difficulties during CEC procedure, whether the benefits of CEC outweigh the risks is still controversial(6).

Objective:

This present study was designed to

•Introduce the evolution of access cavity in endodontics.

•Summarize the previous studies given that some results of the studies are contrary, and it might be doubtful for the readers.

•Evaluate different type of access cavity by comparing the previous studies.

•Make a conclusion regarding the indication of each technique and analyze the benefits and drawbacks of each technique.

Methodology:

Given that the topic was "New trends in designing access cavity in endodontics", only the studies regarding conservative endodontic access cavity from 2010 to 2020 were included. The exclusion criteria for the studies were publication year before 2010 or collected sample less than 30 teeth. Key words: traditional endodontic cavity, contracted endodontic cavities, ninja, truss, fracture resistance, instrumentation efficacy, transportation. Around 15 studies were selected through Pubmed with the university account and downloaded in Mendeley so that citation and references could be inserted correctly with Vancouver style. The studies including the experiment of different access cavity are listed in the following table, and its' results will be analyzed in the discussion.

Incorporating authors	Journal	Publication year	Number of subjects
CorsentinoG, PedullàE, CastelliL, LiguoriM, SpicciarelliV, MartignoniM(22)	Journal of Endodontics	2018	One hundred mandibular first molar teeth
OzyT, OzsezerE(14)		2018	One hundred extracted mandibular first molar
MooreB, VerdelisK, KishenA, DaoT, FrcdC, FriedmanS(27)	Journal of Endodontics	2016	Fifty-nine extracted intact maxillary molars
Chih-Yu Lin, Dan Lin,	Journal of	2020	Forty-five intact

Wei-Hung He(6)	Endodontics		extracted teeth were selected
AlovisiM, PasqualiniD, MussoE, BobbioE, GiulianoC, MancinoD(17)	Journal of Endodontics	2018	Thirty extracted human mandibular molars
A. F. A. Barbosa, E. J. N. L. Silva, B. P. Coelho, C. M. A. Ferreira , C. O. Lima & L. M. Sassone(26)		2020	Thirty extracted intact mandibular molars
KrishanR, PaquF, OssarehA, KishenA(28)		2014	Ninety extracted Intact maxillary central incisors, mandibular second premolars, and mandibular first

			molars
PlotinoG, GrandeNM, IsufiA, IoppoloP, PedullàE, BediniR(29)	Journal of Endodontics	2017	One hundred and sixty extracted maxillary and mandibular molars and premolars
Gokhan Saygili, Banu Uysal, Bawar Omar, Elif Tarim Ertas, Huseyin Ertas(30)		2018	Sixty extracted maxillary first molars
Gaya C. S. Vieira, Alejandro R. Perez, Flavio R. F. Alves(31)	Journal of Endodontics	2020	Sixty-two mandibular incisors
Almira Isufi, Gianluca Plotino, Nicola M. Grande, Luca Testarelli(32)	Journal of Endodontics	2020	One hundred and twenty extracted maxillary and mandibular molars and premolars

Results:

Rajesh Krishan *et al*, 2014(28)	The mean load at fracture: Premolars with CEC (586+-116.9N) and with TEC (328+-56.7N). Molars with CEC (1586+-196N) and with TEC (641+-62N)
A. F. A. Barbosa *et al*, 2020(26)	The average failure load TEC group 748+-238 N CEC group 971+-377 N.
Brent Moore *et al,* 2016(27)	Mean proportion of the modified canal wall CECs (49.7%+-12.0%) TECs (44.7%+-9.0%) Mean load at failure

	CECs (49.7%+-12.0%) TECs (44.7%+-9.0%)
Gaya C et al, 2020(31)	Number of bacteria-positive samples CEC group (25/29, 86%) TEC group (14/28, 50%)
Mario Alovisi et al, 2018(17)	Mean volume of removed dental tissue CEC group (23.01+-7.4 mm3) TEC group (53.2+-8.9 mm3) Mean number of pecking motions required TEC group (3.6+-1.6) CEC group (5.1+-2.2)
Gianluca Plotino *et al*, 2017(33)	Mean load at fracture Upper premolars with TEC (around 498) Upper premolars with CEC (around 821) Upper molars with TEC (around 810) Upper molars with CEC (around 1143)
T. Ozy *et al*, 2018(14)	Fracture loads of the roots TEC + EverX Posterior (971.03+-114.28N)

	CEC + EverX Posterior (1008.25+-216.83N) TEC + SDR (1451.92+-205.39N) CEC + SDR (1674.07+-238.36N)
Almira Isuf *et al*, 2020(32)	Percentage of volume of dentin and enamel removed CEC group (up to 15%) TEC group (more than 15%)

Discussion:

Rajesh Krishan *et al*, 2014(28) evaluated the impacts of CEC on different teeth. In the study, mechanical efficacy of canal instrumentation is evaluated with micro–computed tomographic (micro-CT) imaging. Preoperative and postoperative micro-CT images enables measurements of changes in root canal morphology, including volume of the dentin removed and canal wall surface areas untouched by instruments(28)(34). Fracture resistance of teeth is measured by simulated functional loading in the Instron Universal Testing machine until fracture occurs(28)(35). Their findings indicated that larger proportion of untouched canal wall can be observed in the distal canals of molars with conservative endodontic cavities and there were no significant differences in other tooth types. Therefore, CEC compromises the instrumentation efficacy in the distal canals of molars. The dentin volume removed was significantly smaller for CEC than for TEC in incisors, premolars, molars all 3 tooth types. Furthermore, the fracture resistance for CEC was significantly higher than for TEC in premolars and molars and no remarkable differences in incisors. More importantly, molars and premolars with CEC presented similar fracture resistance to intact teeth of the same type; however, teeth with TEC were much less resistant than intact teeth(28).

In addition, Rajesh Krishan *et al*, 2014(28) advocated that CEC deserves to be considered as a preferable cavity for mandibular premolars. They found out that CEC on mandibular molars has an advantage of increased fracture strength and disadvantage of compromised canal instrumentation in the distal canals. Given that proper widening of the distal outline of CEC might reduce the risk of compromised canal instrumentation(28)(29), they stated that even in mandibular molars, CEC deserves to be considered as a preferable cavity design. They mentioned the importance of minimally invasive procedures and recommended the clinicians to sharpen their skills to be able to work effectively in confined spaces.

The study by A. F. A. Barbosa *et al*, 2020(26) evaluated the impacts of CEC on mandibular molars. In the study, the surface area, unprepared area, volume of dentine removed and the overall root canal filling quality were calculated by a software “3D Slicer 4.4.0.” The root canals were contaminated by a culture of enterococcus faecalis so that the level of microbial reduction could be evaluated later on(26). Fracture resistance was measured by a universal testing machine callled EMIC DL2000 with continuos compressive force(26). The results indicated that conservative endodontic access cavities did not provide any benefits compared with the traditional endodontic access cavities regarding microbial reduction in canals after final irrigation, volume of dentine removed, centring ability and transportation(26), and there are more unprepared canal wall areas in conservative approaches compared to the traditional endodontic access cavities. In addition, there is no significant differences regarding the average failure load among the group TEC and CEC. A. F. A. Barbosa *et al*, 2020(26) concluded that conservative approaches were associated with larger volumes of filling material remnants within the pulp chamber, which is in line with the findings of Rajesh Krishan *et al*, 2014(28). It indicates that adequate cleaning of pulp chamber and manipulation of instrumentation are more difficult in small access cavities. However, A. F. A. Barbosa *et al*, 2020(26) found out that there was no positive influence regarding fracture resistance of mandibular molars(26), which is contrasting to the findings of Rajesh Krishan *et al*, 2014(28). It might be due to the restoration of the teeth was carried out before the fracture test in the study by A. F. A. Barbosa *et al*, 2020(26), and the instrumented teeth without restoration were loaded to fracture in the study by Rajesh Krishan *et al*, 2014(28). It has been proved that restored teeth would recover up to 72% of the original fracture resistance when compared to untreated teeth(27,36). One of the limitations of this study is that microbial sampling was performed by paper points. Contamination of root surfaces may not have been detected completely with paper points since it prevents the detection of bacterial biofilms on canal walls; comparatively speaking, pulverization technique enhanced the detection and provided a reliable representation of bacterial sampling(37). However, pulverization technique cannot be used in this study because it will lead to the failure of following assessment because of its destructive nature.

The study by Brent Moore *et al,* 2016(27) evaluated the influence of CECs regarding instrumentation efficacy in maxillary molars. Extracted intact teeth were assigned to CEC and TEC group. Imagination of micro-CT allows verification of instrumentation efficacy. The fracture resistance was measured by Instron Universal Testing machine, and the axial strain was recorded before cavities performed and after instrumentation completed(27). The teeth were fatigued periodically and it was compressed by continuous force afterwards. It found out that there was no significant differences between CECs and TECs regarding instrumentation efficacy, besides, there was no significant advantages regarding fracture strength of CEC on maxillary molars compared with TEC on maxillary molars(27). This result is contrasting to the findings of A. F. A. Barbosa *et al*, 2020(26) regarding impacts of instrumentation efficiency of CEC. Brent Moore *et al,* 2016(27) stated that there is no significant difference regarding instrumentaton efficiency between CEC and TEC. It might be due to the differences of the type of teeth included. Brent Moore *et al,* 2016(27) selected maxillary molars as samples, and A. F. A. Barbosa *et al*, 2020(26) used mandibular molars as samples. The findings of A. F. A. Barbosa *et al*, 2020(26) and Brent Moore *et al,* 2016(27) both presented that there is no significant difference on fracture resitance between CEC and TEC. Brent Moore *et al,* 2016(27) neither supported nor opposed the uses of CEC on maxillary molars. They stated that due to the complication of root canal systems in maxillary molars, and complication of localizing secondary canal in mesiobuccal root (38). The utilization of CEC on maxillary molars should be carefully assessed by the clinician individualy. However, Gokhan Saygili *et al*, 2018(30) evaluated the secondary mesiobuccal canal detection ratio of different endodontic Access Cavity types in the upper first molars. They selected 60 extracted maxillary first molars. The canals were searched after each group of cavities prepared. The weight of the teeth were calculated pre-operatively and post-operatively(30). They found out that the secondary mesiobuccal detection rate of conservative endodontic cavity (%53,3) and traditional endodontic cavity (%60) are similar. In other words, it was concluded that the use of conservative endodontic cavity in upper molars seems reasonable in the matter of detecting secondary mesiobuccal canal and the removal of hard tissue; however, the clinicians have to take their own knowledge and technique into account.

Gaya C et al, 2020(31) evaluated the impacts of minimally invasive endodontic regarding the disinfection and shaping of oval canals of mandibular incisors. The samples were divided into conservative and traditional access cavities, and a pure culture of Enterococcus faecalis contaminated the canals for 30 days(31). Intracanal bacteriologic samples were taken pre-operatively and post-operatively. (31). Micro-CT scans were used to evaluate the shaping. It found out that bacterial counts in the traditional cavity group were 82% lower than in the contracted cavity group, which is contrasting to the result by A. F. A. Barbosa *et al*, 2020(26). It is due to the difference of methodologies. Gaya C et al, 2020(31) selected 30 manibular incisors and A. F. A. Barbosa *et al*, 2020(26) selected 30 mandibular molars. Furthermore, Gaya C et al, 2020(31) performed additional steps during the procedure of bacteriological sample taking, for instance, they sealed the apical foramen of all the samples with Topdam material, which is useful for avoiding bacterial leakage and simulating the vapor lock effect by creating a closed-end system. Nevertheless, both studies had the same limitation, which is using paper points for bacteriologic sampling. This method cannot discover the exact localization of the residual bacteria, it only evaluates the approximate bacteriologic conditions in the main canal(31,39).

Gaya C et al, 2020(31) found out that there were no significant differences regarding the volume of unprepared areas in canals between the contracted and traditional endodontic cavity groups (31), which is in agreement with Brent Moore *et al,* 2016(27) and conflicting with Barbosa *et al*, 2020(26). Brent Moore *et al,* 2016(27) and Gaya C et al, 2020(31) had the similar result even though they used different instruments. The disagreement of Barbosa *et al*, 2020(26) and Gaya C et al, 2020(31) may be due to the teeth selected and the instruments selected. Gaya C et al, 2020(31) utilized the XP-endo Shaper for root canal instrumentation, and Barbosa *et al*, 2020(26) selected Reciproc Blue R25 (VDW, Munich, Germany). XP-endo Shaper was a recently introduced instrument and it was designed to touch more walls than traditional instruments without removing excessive structure due to its flexibility and snake shape(40). It was concluded by Gustavo De-Deus et al, 2019(40) that the XP-endo Shaper showed a higher percantage of root filling removal.

Mario Alovisi et al, 2018(17)" assessed the influence of Contracted endodontic cavities on the preservation of the original canal anatomy after shaping with nickel-titanium rotary instruments. Thirty extracted human mandibular molars with fully formed apices and independent mesial canals were randomly assigned to group Contracted endodontic cavities and group traditional endodontic cavities(17). Micro-CT analyses were performed before and after shaping, and images were analyzed to evaluate canal volumes, surface areas, and centroid shift on cross sections at 1 mm and 3 mm from the apex. They found out that there were several pecking motions observed in the CEC group, and TEC presents a better preservation of the original canal anatomy during shaping compared with CEC, particularly at the apical level. In the findings of Mario Alovisi et al, 2018(17), there were more apical transportations observed in the CEC group compared with the TEC group. It was possibly related to the presence of coronal interferences (17,27–29).These results differ from the findings of A. F. A. Barbosa *et al*, 2020(26). It is probably due to the difference of instruments for the preparation. A. F. A. Barbosa *et al*, 2020(26) carried out the instrumentation with Reciproc Blue R25 and Reciproc Blue R40. Mario Alovisi et al, 2018(17) used WaveOne Gold (Dentsply Maillefer) for shaping. Regaing the manufacture of Reciproc Blue, it was coated by an oxide layer, which may enhance the flexibility. In addition, It has been proven that the cyclic fatigue resistance of Reciproc Blue was higher than of WaveOne Gold(41). These differences might affect the number of pecking motions required during instrumentation and the outcome of transportation.

Gianluca Plotino *et al*, 2017(33) selected 160 teeth including 40 maxillary first molars, 40 mandibular first molars, 40 maxillary first premolars, and 40 mandibular first single-rooted premolars. All types of teeth were drilled with the same type of bur. The canals were filled with gutta percha and at the end, the access cavities were restored with composite restorations(33). To simulate the oral environment, the teeth were mounted on brass rings with the roots embedded in self-curing resin up to 2 mm apical to the CEJ while loaded in a mechanical material testing machine (LR30 K) for fracture test(33). The maximum load at fracture was recorded; moreover, the fracture was classified into restorable or unrestorable depends on the site of fracture. The statistics indicated that the mean load at fracture for teeth of TEC group was significantly lower than the CEC group(33). The findings of Gianluca Plotino *et al*, 2017(33) revealed that the mean load at fracture for teeth of TEC group was significantly lower than the CEC. This result are in line with the study by Rajesh Krishan *et al*, 2014(28). Although the methods were different, both of them reached the same results. Rajesh Krishan *et al*, 2014(28) tested fracture resistance without restoration, unlike Gianluca Plotino *et al*, 2017(33) tested after restoration. However, some recent studies manifested that CEC does not have positive impacts on fracture resistance compared with TEC such as Barbosa *et al*, 2020(26), Brent Moore *et al,* 2016(27), T. Ozy *et al*, 2018(14)…etc. This contrasting finding might be associated with lots of factors, including the type of teeth selected, the endodontic and restorative materials chosen, the approaches to test the fracture resistance(27,28,33). Regarding the method of fracture test, Both Gianluca Plotino *et al*, 2017(33) and Rajesh Krishan *et al*, 2014(28) mounted the samples on brass rings with the roots embedded in self-curing resin up to 2 mm apical to the cementoenamel junction. Brent Moore *et al,* 2016(27) mounted the teeth up to 3 mm apical to the cementoenamel junction in customized cylinders fabricated with self-curing resin, with a 0.2-mm-thick lining of polyvinyl siloxane simulating the periodontal ligament. In addition, Brent Moore *et al,* 2016(27) carried out a distinct method, the teeth were subjected to 1 million loading cycles in the Instron Universal Testing machine to simulate approximately 4 years of chewing function within the physiological forces(27). This extra method made the samples more similar to the intraoral condition in reality compared with other studies. Therefore, it further validated the result.

T. Ozy *et al*, 2018(14) aimed to compare the fracture strength of mandibular molar prepared with CEC and TEC, and restored with SDR and EverX Posterior base composite materials(14). The samples were divided into TEC prepared with SDR restored, TEC prepared with EverX restored, CEC prepared with SDR restored, and CEC prepared with EverX restored. All the teeth were kept in distilled water at room temerature for 24 hours before the fracture test(14), and the fracture test was carried out by an Instron Universal Testing

Machine(Instron, Buckinghamshire, UK). The fractures were recorded as restorable if it was above the level of bone simulation and unrestorable if it was below the level of bone simulation. Among the different groups, the highest fracture resistance was presented in group TEC+SDR and group CEC+SDR(14). The results manifested that there was no statistically significant difference regarding fracture strengths of TEC and CEC preparation with the same restorative material. In addition, the manipulation of restorative materials in CEC preparation was more difficult than TEC preparation(14). Unlike most of the studies preparing occlusal cavities, the study by T. Ozy *et al*, 2018(14) imitated the interproximal caries, which explained the class II cavitys prepared. It was concluded that there was no statistically significant difference regarding fracture strengths of TEC and CEC preparation with the same restorative material. However, they found out that the manipulation of restorative procedures in CEC is more complicated, which might compromise the achievement of correct restoration.

Almira Isuf *et al*, 2020(32) compared the difference between ultraconservative endodontic cavity (UEC), conservative cavity and traditional cavity regarding the amount of removed dentin and enamel. The teeth were scanned by CBCT before and after access cavity preparation. The sliced image data were imported into the MeVisLab framework system. The percentage of volume of dentin and enamel removed for each endodontic access cavity preparation was measured(32). They found out that the percentage of volume of dentin and enamel removed in UEC (less than 6%) and CEC (8.1%-14.2%) was significantly lower than in TEC (16%-19.2%) in all of the tooth types(32). One of the limitation of this study was that the maximum and minimum values of dentin and enamel removed in each of the group were similar to the mean of the other groups. However, it at least proposed the benefit of "conservative concept" according to the percentage of volume of dentin and enamel removed.

All in all, CEC might compromise the detection of extra canals and complicate the manipultaion of instumentation and obturation. So far, the incidence of instrument fracture has not been assessed yet in any article, it is a subject worthy to be focused on. Further studies are required and there are more aspects have to be taken into account. For instance, if the knowledge and the technique of clinician would affect the detection rate and the difficulty of instrumentation and obturation(19).

On the other hand, due to the limitation of sampling technique, the influence of CEC on microbial reduction is still imprecise. Further studies with different technique are required to confirm the results. It is clear that the dentin would be preserved more in CEC, which validates the concept of "conservative dentistry." However, given the statitics so far, most of the studies concluded that CEC had no significant impact on fracture resistance compared with TEC. There are a lot of uncertainties would affect the results. For example, tooth age is a vital factor that affect the tooth strength and durability. It is recommended to be considered in sample selection; nonetheless, it has been neglected in most of the included articles(19). Furthermore, internal and external anatomy of teeth, such as the width of pulp chamber, crown morphology, would affect the value of fracture resistance test. Most of the studies carried out sample selection by 2D radiogragh and direct measurement. In future studies, it is worthy to be considered using CBCT or micro-CT technologies so that the reliability and accuracy of sample selection can be further validated. Besides, there are plenty of factors might affect the outcome of fracture resistance test, such as the storage of extracted teeth, the technique of extraction carried out by clinician. This information is always encouraged to be reported(19).

Some studies have divided the samples into TEC and CEC, but the concept of ultra-conservative cavity was included in some studies as well. The definition of different cavities has always been debatable, and the cavities carried out were based on the experience of cliniclian. There are different access can be considered as CEC due to the ambiguous and undefined terminology. Therefore, it might confuse the reader because of the misconception of different designs. For example, the term contracted was meant to define a “conservative” access cavity, but often its design was more associated with the design of an ultraconservative cavity(27,32). On the other hand, the “traditional” cavities that they performed might be more conservative than the definition of TEC in reality(32). Furthermore, the force applied to the samples in every studies was not as dynamic as the force in reality, and lots of intraoral factors such as PH changes, temperature changes, saliva were not simulated(14). Future research should focus on simulating the intraoral condition as much as possible.

In general, it is advisable to shift the modern dentistry toward a minimally invasive concept, but it is also indespensable to perform sufficient endodontic access for adequate operating space(17). In previous studies, most of the endodontic access were performed in extracted human teeth and it was challenging even under this condition, not to mention when actually treating a patient. It is always unworthy that the clinicians merely want to preserve the tooth substance and sacrifice the completeness of treatment. After all, the overall success of endodontic treatment is the main objective that every clinicians are tying to achieve.

At this point in time there are no clear benefits to support the use of Conservative endodontic cavities. In addition, there is no randomized controlled trials regarding conservative endodontic cavities so far, the long-term prognosis and durability of the teeth with conservative endodontic cavities are still unknown. Furthermore, patient-related factors such as periodontitis, bruxism can be presented in clinical trials, which is impossible to be simulated in laboratory conditions(19). Therefore, whether conservative endodontic cavities are recommendable in daily practice should require further studies with more samples and randomized controlled trials in the future.

Conclusion:

Within the limitations of the studies so far, no positive impacts have been found utilizing Conservative endodontic cavity in incisors, and there are no clear benefits using Conservative endodontic cavities in all respects. In addition, considering that most of the studies found no positive impacts regarding fracture resistance of Conservative endodontic cavities and given the complicated manipulation of Conservative endodontic cavities. Nowadays, the use of traditional endodontic cavity in daily practice is sufficient to solve most of the cases. There is a lack of supporting evidence to promote conservative endodontic cavities in clinical practice and no adequate reasons to develop the training of this technique in dental clinicians. In short, the use of conservative endodontic cavities is not necessary in all type of teeth until the further randomized controlled trials existed in the future.

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Annexes with front page:

1. ReehES, MesserHH, DouglasWH. Reduction in Tooth Stiffness as a Result of Endodontic and Restorative Procedures. 1989;15(11):512–6.

Reduction in Tooth Stiffness as a Result of Endodontic and Restorative Procedures

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Endodontically treated teeth are thought to be more susceptible to fracture as a result of the loss of tooth vitality and tooth structure. This study was designed to compare the contributions of endodontic and restorative procedures to the loss of strength by using nondestructive occlusal loading on extracted intact, maxillary, second bicuspids. An encapsulated strain gauge was bonded on enamel just above the cementoenamel junction on both the buccal and lingual surfaces, and the teeth were mounted in nylon rings leaving 2 mm of root surface exposed. Under load control, each tooth was loaded at a rate of 37 N per s for 3 s and unloaded at the same rate in a closed loop servo-hydraulic system to measure stiffness. A stress-strain curve was generated from each gauge prior to alteration of the tooth and after each procedure performed on the tooth. Cuspal stiffness, as a measure of tooth strength, was evaluated on one of two series of sequentially performed procedures: 1. (a) unaltered tooth, (b) access preparation, (c) instrumentation, (d) obturation, and (e) MOD cavity preparation; or 2. (a) unaltered tooth, (b) occlusal cavity preparation, (c) two-surface cavity preparation, (d) MOD cavity preparation, (e) access, (f) instrumentation, and (g) obturation. Results on 42 teeth indicate that endodontic procedures have only a small effect on the tooth, reducing the relative stiffness by 5%. This was less than that of an occlusal cavity preparation (20%). The largest losses in stiffness were related to the loss of marginal ridge integrity. MOD cavity preparation resulted in an average of a 63% loss in relative cuspal stiffness. The results indicate that endodontic procedures do not weaken teeth with intact marginal ridges.

Endodontic treatment is considered to weaken the tooth by increasing the brittleness, leading to a higher susceptibility to fracture. Consequently, the recommended restoration has been cuspal protection with a cast restoration. Clinical studies on large numbers of patients have indicated the need for special restorative considerations for endodontically treated teeth (1–3). One of the largest difficulties with retrospective studies is that only the clinically successful cases are examined (1). The greatest failure rate in endodontically treated teeth was associated with lack of appropriate restoration (2, 3). Teeth are believed to become more brittle as a direct result of endodontic treatment leading to fracture and tooth loss (4). In reality increased brittleness has not been proven. Hardness measurements of endodontically treated teeth that were treated up to 10 yr previously indicated no difference in hardness between endodontically treated and vital teeth (5). Similiarly, punch shear testing on endodontically treated teeth showed only a small (although statistically significant) reduction in strength of 14% (6).

Restorative procedures (not in relation to endodontic treatment) have been examined to determine their contribution to the resistance of the tooth to fracture. Statistical differences were difficult to demonstrate for restorative procedures due to the destructive nature of these tests. To overcome the problem of sample variation, large numbers of samples are needed. It has been shown that the resulting weakening of the tooth due to restorative procedures increases with the reduction of tooth structure (7, 8). According to Larson et al. (8) occlusal cavities significantly weaken the tooth and wider isthmus preparations result in the largest decrease of tooth resistance to fracture. Factors such as the maintenance of marginal ridge integrity and width of the isthmus region also appear to be important in reducing tooth fracture (7, 9). The conclusions that could be drawn from previous work are that the preservation of tooth structure is important in maintaining resistance to fracture, especially by preserving marginal ridges and maintaining narrow isthmus.

According to Hood (10), nondestructive techniques employing linear variable differential transformers, which measure small movements of tooth structure under load, provide one method to examine the effects of sequential treatments. The relative contributions of restorative and endodontic procedures could be more accurately assessed, within physiological limits, using this technique. Hood observed that a small reduction of tooth structure, such as an occlusal cavity preparation, produced a significant decrease in tooth rigidity. Endodontic procedures also significantly decreased tooth rigidity reflecting a decreased stiffness in the tooth (10).

Other sources are in agreement that the removal of hard tissue increased cuspal flexure under occlusal load (11, 12). Morin et al. (13) state that the use of strain gauges also permit the visualization of hysteresis. Hysteresis, which is the state of being behind, in strain gauge measurements would be the

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Identifying and Reducing Risks for Potential Fractures in Endodontically Treated Teeth

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Abstract

Introduction: Although long-term functional survival rates can be high for initial endodontically treated permanent teeth, they are generally more susceptible to fracture than teeth with vital pulps. Tooth extraction is often the consequence of an unfavorable prognosis after coronal and root fractures, but their occurrence in endodontically treated teeth might be reduced by identifying the risks for fracture associated with various operative procedures. **Methods:** This article presents an overview of the risk factors for potential tooth fractures in endodontically treated teeth on the basis of literature retrieved from PubMed and selected journal searches. **Results:** Postendodontic tooth fractures might occur because of the loss of tooth structure and induced stresses caused by endodontic and restorative procedures such as access cavity preparation, instrumentation and irrigation of the root canal, obturation of the instrumented root canal, post-space preparation, post selection, and coronal restoration and from inappropriate selection of tooth abutments for prostheses. **Conclusions:** Potential tooth fractures might be reduced by practitioners being aware during dental treatments of controllable and noncontrollable risks. *(J Endod 2010;36:609–617)*

Key Words

Endodontic treatment, risk factors, tooth fractures

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Although the long-term functional survival of initial endodontically treated permanent teeth was reported as 97.1% after 8 years in a very large epidemiologic survey (1), coronal and/or radicular tooth fractures continue to remain important reasons for postendodontic tooth repairs and extractions (2, 3). A 5-year follow-up survey involving 857 randomly selected teeth with nonsurgical root canal treatment found that 18 (28.1%) of the total 64 tooth extractions performed by the dentists were attributed to nonspecific tooth fractures (4). Relatively few large clinical studies from general practices have examined the prevalence and incidence of complete and incomplete coronal and/or radicular fractures in restored and nonrestored teeth with either vital pulps or endodontically treated nonvital pulps and with either complete or incomplete root formation. Most of the clinical reports have been of findings from surveys and retrospective studies, of which several were conducted in institutions.

Apart from those tooth fractures caused by sudden impact trauma, postendodontic tooth fractures have generally been attributed to weakened tooth structure caused by incomplete root formation, dental caries, tooth wear, and operative dentistry procedures and from changes in tooth structure caused by aging, vital pulp tissue loss, and endodontic therapy (5). These fatigue failures of tooth structure and restorative materials in endodontically restored teeth might result from normal functional stresses and from increased functional and parafunctional stresses.

Because increasing numbers of elderly persons want to retain their remaining dentitions for as long as possible, increasing numbers of teeth now require endodontic therapy. Many of these remaining teeth show the adverse effects of severe "wear and tear" from previous dental conditions and/or restorative treatments, with an increased risk for postendodontic tooth fractures. Although the causes are multifactorial, many such fractures undoubtedly result from inappropriate treatment planning and endodontic and restorative procedures undertaken by dental practitioners. Therefore, the purpose of the present article is to identify and reduce the risks for potential tooth fractures.

Methods

Publications in PubMed were initially searched by using the key words "endodont* AND tooth fracture OR root fracture." Further articles were gleaned from references listed in the publications and related articles and from searching selected journals.

Results

Prevalence and Incidence of Tooth Fractures

After excluding tooth fracture caused by sudden impact trauma, the American Association of Endodontists has classified 5 variations of longitudinal tooth fracture: enamel craze lines, fractured cusp, cracked tooth, split tooth, and vertical root fracture (6).

One 15-week study involving 11 dentists reported 543 tooth fractures, of which 85.6% were complete cusp fractures, 13.4% incomplete or suspected cusp fractures, and 0.9% root fractures (7). Some 3% of the fractured teeth had not been restored previously, and most of the 377 cusp fractures that were not associated with caries occurred in teeth with vital pulps. This study also reported that during any given year some 6% of adult patients with at least 1 posterior tooth at risk would experience a complete posterior cusp fracture in the absence of caries, with an incidence rate of 72.7 per 1000 person-years at risk. The noncarious fracture rate experience for anterior teeth was far lower. In the subsequent 1- to 2-year follow-up study of 517 previously

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Fracture strength of human teeth with cavity preparations

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Failure of dental restorations is a major concern. The most common causes are faulty cavity preparation and improper manipulation of restorative materials. Another cause of failure is the geometric form of the cavity preparation, which may lead to fracture of the tooth.

The anatomic forms of posterior teeth with cusps and fossae present a design possessing a tendency to deflect the cusps under stress (Fig. 1, *A*).[1] While sound teeth rarely fracture from the stresses of mastication, fracture of a cusp may occur in teeth which have been weakened by caries and the cavity preparation required for restoration.

The typical intracoronal cavity preparation, especially in the maxillary premolars, exaggerates the height of the cusps (Fig. 1, *B*). The weakened or unsupported cusps are subjected to stresses which tend to deflect or fracture them at the buccopulpal or linguopulpal line angles (Fig., 1, *C*). While a fracture may not occur, deflection of a weakened cusp may open the tooth-restoration interface and lead to subsequent marginal leakage (Fig. 1, *C*). It is evident that the buccolingual width of the occlusal preparation may contribute toward weakening of the cusps.

Cavity forms have been based on Black's principles.[2] For Class I and II cavity preparations, Black advocated an occlusal width of one-third the buccolingual intercuspal distance. Present-day equipment and restorative materials permit more conservative geometric forms. Modern cavity preparation permits narrow occlusal designs, one-fourth the buccolingual intercuspal dimension.[1, 3-8] Vale[9, 10] investigated the effect of the buccolingual width of MOD cavity preparations prepared in sound teeth. His stress studies encouraged conservative cavity preparations. However, a well-controlled investigation of the effects of stress upon the cusps of occlusal preparations of various widths should ascertain the validity of conservative occlusal preparations.

This article reports the fracture strength of teeth prepared with three buccolingual widths of occlusal preparations.

MATERIALS AND METHODS

Freshly extracted sound premolars from patients 20 to 25 years of age were cleaned and fixed in neutral formalin for 72 hours.[11] Only teeth which fell within the range of dimensions established by Galan[12] were accepted for testing. The teeth were examined by stereoscopic microscopy. Those with cracks or fractures were rejected.

The roots of the teeth were embedded in a self-curing polystyrene resin which did not develop exothermic heat.[11] The exposed crown was maintained in a vertical position by a metal brace. The teeth, with roots embedded in the polystyrene base, were stored in distilled water. The period of storage did not exceed 1 week after extraction.

The cavities were prepared with a No. 169 smooth-tapered fissure bur under high speed and finished with the same bur under conventional speed and with hand instruments.

Class I occlusal preparations. The buccal and lingual walls were parallel to each other. The mesial and distal walls diverged slightly toward the occlusal. The mean cavity depth was 2.5 mm.

The cavities were prepared to satisfy three critical dimensions of the isthmus. These differed in the buccolingual width as a fraction of the intercuspal

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Collagen Degradation in Endodontically Treated Teeth after Clinical Function

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ABSTRACT

Endodontically treated teeth restored with posts are susceptible to coronal leakage after long-term function. We hypothesize that demineralized collagen matrices (DCMs) created in dentin by acidic zinc phosphate cement within the dowel spaces degrade with time. Forty-two post-restored teeth were extracted after three periods of clinical service and were examined, by means of scanning and transmission electron microscopy, for the status of the DCMs. SEM revealed a progressive degradation of the DCMs, becoming less dense after 3 to 5 years, losing structural integrity after 6 to 9 years, and partially disappearing after 10 to 12 years. TEM revealed evidence of collagenolytic activity within the DCMs, with loss of cross-banding and unraveling into microfibrils, and gelatinolytic activity that resulted in disintegration of the microfibrils. Bacterial colonization and the release of bacterial enzymes and of host-derived matrix metalloproteinases may contribute to the degradation of collagen fibrils in root dentin after clinical function.

KEY WORDS: *In vivo*, root dentin, collagen fibrils, bacteria, matrix metalloproteinases.

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INTRODUCTION

It is well-established that coronal leakage is a potential cause of failure in endodontically treated teeth (Saunders and Saunders, 1994). This problem can be more pronounced after post preparation, when only relatively short (*ca.* 4-5 mm) lengths of obturating materials remain in the canals (Barrieshi *et al.*, 1997; Fox and Gutteridge, 1997; Metzger *et al.*, 2000; Abramovitz *et al.*, 2001). Although coronal leakage has been substantially reduced with the use of adhesive secondary resin seals (Galvan *et al.*, 2002) and resin cements (Fogel, 1995), zinc phosphate cement is still used in some parts of the world for luting of metal posts and crowns. Most adhesive resin cements cannot guarantee a fluid-tight seal that prevents the ingress of oral fluids, bacteria, and endotoxins (Alves *et al.*, 1998), particularly after long periods of simulated intra-oral function (Reid *et al.*, 2003). It is also unlikely that zinc phosphate cement, that exhibited the most severe initial microleakage (Bachicha *et al.*, 1998), can sustain a long-term seal over years of clinical service.

Bacterial infection caused by coronal leakage remains the central issue in endodontic failure, but very few studies have examined the condition of root canal dentin in post-restored teeth. Zinc phosphate is an initially acidic, non-bonding cement that has the capacity to dissolve the smear layer and demineralize the underlying intact dentin (Shimada *et al.*, 1999). Recent *in vitro* studies have reported the disappearance of denuded collagen fibrils within incompletely resin-infiltrated regions of dentin hybrid layers (De Munck *et al.*, 2003). It is expected that teeth restored with zinc-phosphate-cemented posts and retrieved after long periods of intra-oral function are useful as *in vivo* models for examining the course of degradation of collagen fibrils.

Thus, the objective of this study was to test the hypothesis that denuded collagen fibrils that are exposed by zinc phosphate cement in dentin lining dowel spaces degrade with time. The null hypothesis tested was that clinical aging has no effect on the integrity of root dentin collagen matrices adjacent to metal posts that are luted with a conventional non-bonding cement.

MATERIALS & METHODS

Forty-two clinically asymptomatic, endodontically treated teeth that were scheduled for extraction because of prosthodontic or periodontal reasons were selected. These teeth were all previously root-filled with gutta-percha and Grossman's sealer by means of a lateral condensation technique, with additional dowel spaces prepared and with metal posts cemented with zinc phosphate cement. Half of these teeth were restored with metal crowns, while the remaining functioned as abutments of fixed partial dentures. The metal posts inserted into these teeth included 9 tapered self-threading posts, 15 parallel-sided threaded metal posts, and 18 cast dowel-core that were all cemented with zinc phosphate cements.

The study protocol was approved by the Commission for Medical Ethics of Siena University, Italy. The patients were informed of the intent of the study, and their written consents were obtained. Five teeth had been endodontically treated 12 years previously, 7 teeth had been treated 10 years previously, 14 teeth 8 years

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Influence of restorative technique on the biomechanical behavior of endodontically treated maxillary premolars. Part I: Fracture resistance and fracture mode

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Statement of problem. Unresolved controversy exists concerning the preferred cavity design and restorative technique used to restore endodontically treated maxillary premolars to improve their resistance to fracture under occlusal load.

Purpose. The purpose of this study was to evaluate the fracture resistance, stress distribution, and cusp deformation of endodontically treated human maxillary premolars restored with different materials. The study is divided into 2 parts. In Part I, fracture resistance and fracture mode were determined.

Material and methods. Seventy noncarious human maxillary premolars were selected and divided into 7 groups (n=10). The control group, ST, consisted of sound unprepared teeth. Teeth in the other 6 groups were endodontically treated and each received 1 of 2 cavity preparation designs: MODd, direct mesio-occlusal-distal preparation; MODi, indirect mesio-occlusal-distal preparation. Teeth were restored with 4 types of material: AM, MODd restored with amalgam; CR, MODd restored with composite resin; LPR, MODi restored with laboratory-processed composite resin; and LGC, MODi restored with leucite-reinforced glass ceramic. The fracture resistance (N) was assessed under compressive load in a universal testing machine. The data were analyzed by 1-way ANOVA and the Tukey HSD test (α=.05). Fracture modes were recorded based on the degree of tooth structure involvement and restoration damage.

Results. Statistical analysis showed that the ST group presented the highest fracture resistance values. The restored groups showed significantly higher fracture resistance values compared to the nonrestored groups. The groups restored with adhesive techniques (LPR, CR, and LGC) presented significantly higher fracture resistance values than the group restored with the nonadhesive technique (AM) (P<.001). The catastrophic fractures were prevalent in MODd, MODi, AM, and LPR groups, and less severe fractures were found in ST and LGC groups. For the CR group, there was no prevalent fracture mode.

Conclusions. Teeth with the greatest amount of remaining tooth structure and those restored using adhesive technology showed higher fracture resistance values. There was great variation in the type of fracture among groups. (J Prosthet Dent 2008;99:30-37)

Clinical Implications

Adhesive restorations using composite resin, laboratory-processed composite resin, and ceramic materials improve the fracture resistance of endodontically treated maxillary premolars with MOD cavity preparations. However, the fracture mode may depend on the mechanical properties of the restorative material.

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6. DdsCL, DdsDL, MsWHDDS. Impacts of 3 Different Endodontic Access Cavity Designs on Dentin Removal and Point of Entry in 3-dimensional Digital Models. J Endod. 2020;46(4):524–30.

BASIC RESEARCH – TECHNOLOGY

Impacts of 3 Different Endodontic Access Cavity Designs on Dentin Removal and Point of Entry in 3-dimensional Digital Models

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SIGNIFICANCE

The present study provides information regarding the average amount of dentin removal required in different endodontic access designs. The study also shows that the central fossa is an appropriate anatomic landmark that could serve as the point of entry in both maxillary and mandibular molars.

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ABSTRACT

Introduction: The purpose of this study was to evaluate the tooth structure theoretically required to be removed in the coronal and cervical regions to accomplish 3 different endodontic access preparations in a novel digital model. The deviation of the center of access cavity from the central fossa will also be measured and compared among the 3 endodontic cavity designs, which in turn may serve as suggested points of entry for different access openings. **Methods:** Twenty-one maxillary molars and 15 mandibular molars were selected and 3-dimensionally imaged with cone-beam computed tomographic imaging. Three-dimensional (3D) volume reconstructions were made and converted into stereolithography files. Digital access cavity preparation was performed on each 3D reconstruction model with the 3 most commonly used endodontic access preparations: minimally invasive (MI), modified straight-line (MS), and traditional straight-line (TS) techniques. After the access cavity outlines were determined, digital sectioning of each reconstructed 3D tooth model was performed orthogonal to the long axis of the tooth at 3 levels: (1) passing through the central fossa, (2) 1.5 mm apical to the central fossa, and (3) 2 mm apical to the cementoenamel junction. The linear distance from the centroid of the access opening to the central fossa was measured to calculate the point of entry, and the amount of tooth structure removal at the pericervical area was measured to calculate the theoretically minimum amount of linear dentin removal required. Two-way repeated measures analysis of variance was performed for the interactions between different access designs and the amount of cervical dentin removal. Other data were statistically analyzed with 1-way repeated measures analysis of variance. The Tukey post hoc test was used for multiple comparisons. Significance was set at .05. **Results:** The amount of deviation of the center of the access cavity from the central fossa in all test groups was less than 1 mm. The dimensions of access openings differed significantly among the 3 access forms (TS > MS > MI, $P < .0001$). The amount of required cervical dentin removal was the greatest in the TS method followed by the MS and MI methods ($P < .0001$). **Conclusions:** The central fossa could serve as good starting points in all access preparations in both maxillary and mandibular molars. Dentin removal in the coronal and cervical regions was the greatest in the TS design followed by the MS and MI designs. When comparing different canals in the same access form, less cervical dentin was sacrificed in the palatal canals of maxillary molars and the distal canals of mandibular molars. *(J Endod 2020;46:524–530.)*

KEY WORDS

Conservative access cavity; dentin removal; endodontic access cavity; point of entry; traditional straight-line access

Since the early 1980s, multiple authors have studied access cavity design, instrumentation techniques, and their effects on minimizing the risks of iatrogenic complications[1–3]. These authors advocated the complete unroofing of the pulp chamber and straight-line access to the level of the midroot canal curvature, whose concepts are now termed the "traditional" access preparation. Unlike the traditional

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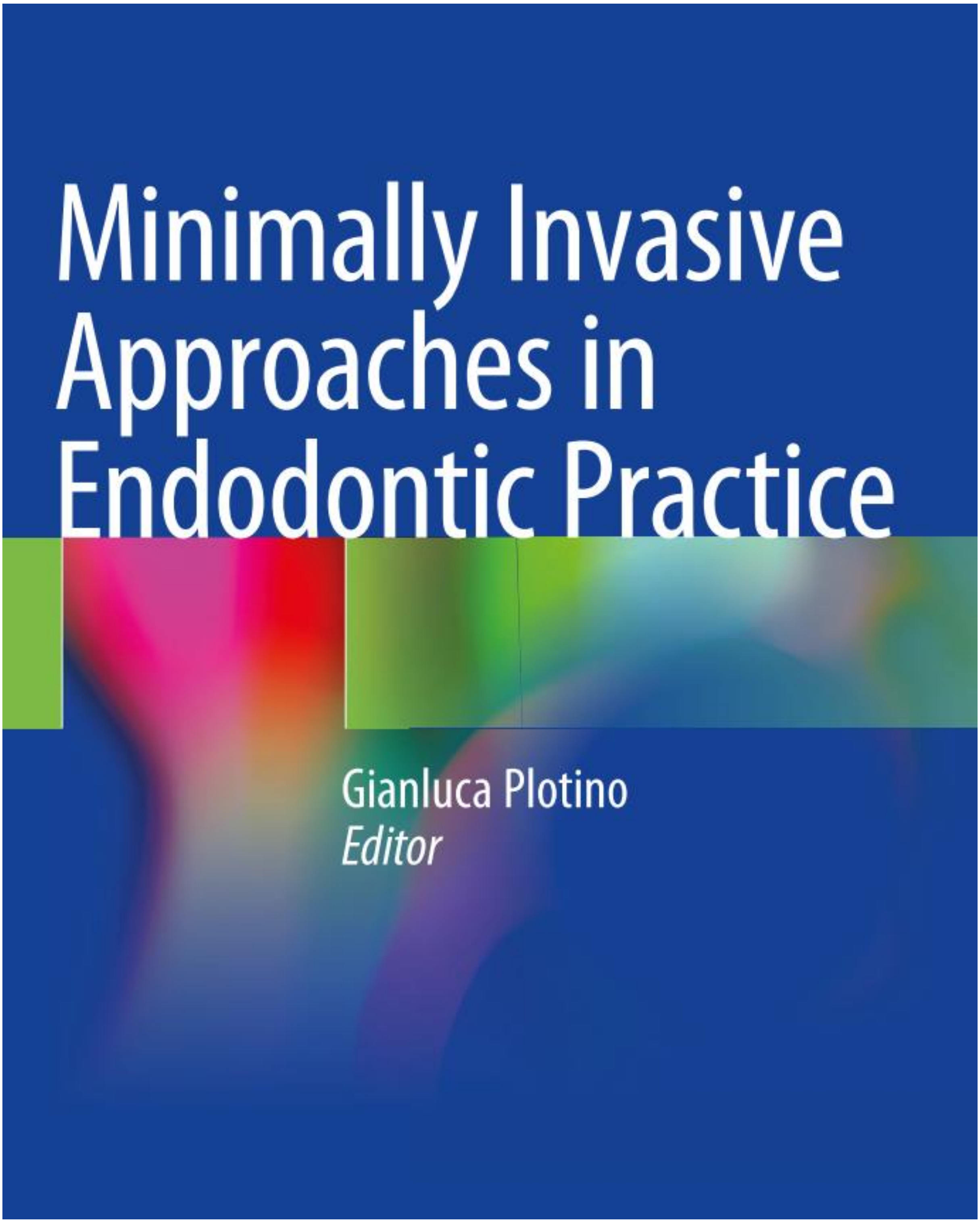

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Conservative endodontics: A truss access case series

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Abstract
The prime objective of this case report is to obtain access cavity designs that is strategic dentin preservation (ie, leaving a truss of dentin between the 2 cavities thus prepared). Three permanent teeth with an indication for endodontic treatment were treated via the truss access cavity design rather than traditional access cavity protocol using copious irrigation. The teeth were then given post-endodontic restorations. Endodontically treated teeth did not show any post-operative symptoms or any presence of post-operative periapical radiolucency or flare-up. Truss access approach mainly emphasizes on the preservation of the healthy tooth structure with the minimally invasive approach. This minimal invasive approach in access opening avoids the need for conventionally placed crowns.

Keywords: Access cavity, truss access, conservative access cavities

Introduction

Endodontic therapy is comprised of three factors which are cleaning and shaping, disinfection and three-dimensional obturation of the root canal system. However, access cavity preparation is known to be one of the most challenging and an important step for a successful endodontic treatment [1].

Weakening of tooth structure is a major drawback in Traditional Endodontic Access Cavity (TEC) mainly due to pathology. For restoration of these teeth, various treatment modalities may be used, ranging from a simple direct restoration with or without a post and core to more complex indirect restorations, including inlay, onlay and full-coverage crowns [2].

TEC has been shown to demonstrate a significantly higher percentage of non-restorable fractures of teeth which was reasoned to be related to the higher volume of coronal tooth structure loss in TEC [3].

To overcome this, Clark and Khademi modified the endodontic access cavity design to minimize the tooth structure removal and this was known as the Conservative Endodontic access Cavity (CEC). The aim of the CEC was to preserve some of the chamber roof and the pericervical dentin [4].

The pericervical dentin is the dentin that is located 4 mm above and 4 mm below the crestal bone and they serve in distribution of functional stresses in teeth. Thus, it is necessary that we preserve this pericervical dentin in order to maintain the biomechanical response of the radicular dentin [5].

Trials of more conservative access cavity designs such as contracted (a small conservative cavity on the occlusal surface that allow the clinician to access all the canal orifices), truss (a direct access from the occlusal surface to expose the mesial and distal canal orifices and leaving the intervening dentin intact), and ninja (ultraconservative approach) access cavity preparation methods have been previously reported to improve fracture resistance of endodontically treated teeth and reduce the dependency on complex, more expensive post endodontic restorations [6]. The differences between traditional access cavity and contracted access cavity is mentioned in Table 1.

One approach of CEC is the orifice-directed design (also called the ''truss'' access cavity), in which separate cavities are prepared to approach the mesial and distal canal systems in a mandibular molar, whereas for maxillary molars the mesio- and distobuccal canals are

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Review Article

UNUSUAL WAYS USUAL DESTINATION

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ABSTRACT

Endodontic access cavity is one of the most important step for a successful endodontic treatment. The design of the traditional endodontic cavity (TEC) for different tooth types has been established several decades ago and has remained unchanged with only minor modifications. In TEC, it has a properly access cavity with straight line access. Whereas in conservative access cavity (CEC), there is preservation of the pericervical dentin and complete deroofing of the roof is avoided.

INTRODUCTION

Endodontic therapy comprised of three factors and they were cleaning and shaping, disinfection and three-dimensional obturation of the root canal system. However, Access cavity preparation is known to be one of the most challenging and important step for a successful endodontic treatment.

Inadequate access cavity preparation may also result in difficulty in locating or negotiating the root canals, instrument separation and aberrations of the canal shape which may result in inadequate cleaning, shaping and filling of the root canal system. This may lead to failure of the treatment. For a long time G. V. Black's preparations were totally accepted by the profession. Traditional endodontic access cavities (TEC), it emphasizes on straight line access into the root canals and this helps to increase the biomechanical preparation efficacy and reduce the procedure errors. However, a concern related to TECs is the amount of tooth structure removed, which may reduce its resistance to fracture under functional loads.[1, 2] The most current evolution is a minimalistic approach to access design by shifting the outline configuration toward greater dentin preservation and idealizing the endodontic-restorative interface.[3]Recently, Clark and Khademi modified the endodontic access cavity design to minimize the tooth structure removal and this was known as the Conservative endodontic access cavity (CEC). The aim of the CEC was to preserve some of the chamber roof and the pericervical dentin.[4]

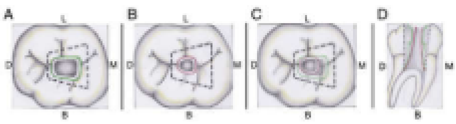

Figure1 (A–D) Sketches with an (A–C) occlusal view and (D) sagittal view of access cavity designs of a first mandibular molar.

(A–D)A traditional access cavity (black line dashed), (A, C, and D) conservative access cavity (green), and (B–D) ultraconservative ''ninja'' access cavity (red). Comparison of the 3 access cavity designs in the (C) occlusal and (D) sagittal view, respectively. The sagittal view shown as a conservative access cavity maintains a robust amount of pericervical dentin. B, buccal; D, distal; L, lingual; M, mesial

Traditional endodontic access cavity

The access cavity preparation depends on the G.V.Black's principles. One of its fundamental concepts, 'extension for prevention', had been followed universally for many decades. A little modification of the principles and they include the outline form, the convenience form, removal of the carious dentin and the toilet of the cavity[6]

During cavity preparation, the centre of the pulp chamber should be the target of the initial penetration, at a point where the roof and floor of the pulp chamber are at the widest. The outline form is then determined by the shape of the pulp chamber which also determines the occlusal extent of the

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10. PeerM. Intentional replantation a ` last resort ’ treatment or a conventional treatment procedure ? Nine case reports. 2004;48–55.

Dental Traumatology 2004; 20: 48–55

DENTAL TRAUMATOLOGY

Case Report

Intentional replantation – a 'last resort' treatment or a conventional treatment procedure? Nine case reports

Peer M. Intentional replantation – a 'last resort' treatment or a conventional treatment procedure? Nine case reports. Dent Traumatol 2004; 20: 48–55. © Blackwell Munksgaard, 2004.

Abstract – Intentional replantation is an accepted endodontic treatment procedure in which a tooth is extracted and treated outside the oral cavity and then inserted into its socket to correct an obvious radiographic or clinical endodontic failure. This article reviews nine cases of intentional replantation (IR) that show the feasibility of the procedure in a variety of indications. Only one case of replantation showed evidence of pathosis that reflected root resorption or ankylosis. This report suggests that IR is a reliable and predictable procedure and should be more often considered as a treatment modality in our efforts to maintain the natural dentition.

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Key words: intentional replantation; ankylosis; periradicular surgery; apical periodontitis; apical surgery; external root resorption

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Although non-surgical endodontic procedures have a high success rate, failures do occur (1–3). These can be managed by root canal re-treatment or endodontic surgical intervention (4). The purpose of this article is to present intentional replantation (IR) as a reliable and predictable procedure that may be regarded as a potential option when considering endodontic periradicular surgery.

Definition

Intentional replantation is an accepted endodontic treatment procedure in which a tooth is extracted and treated outside the oral cavity and then inserted into its socket to correct an obvious radiographic or clinical endodontic failure (5).

Indications

Intentional replantation is indicated when other endodontic treatments performed to maintain the tooth have failed, or when endodontic periradicular surgery is not feasible.

- *Failure of root canal treatments*: If conventional root canal therapy, non-surgical re-treatment, and surgical re-treatment have failed, intentional replantation may be indicated.
- *Anatomic limitations*: Proximity of the treated root apex to nerves such as the mandibular or mental nerve, or to anatomic structures such as the maxillary sinus can present problems with periradicular surgery, and IR should be considered as an alternate treatment.
- *Accessibility problems*: Periradicular surgery on mandibular molars can be difficult because of dense buccal bone (external oblique ridge) and lingual root inclination.
- *Patient management*: A procedure such as periradicular surgery, which requires patient cooperation, especially when using the microscope, can be difficult to perform. Intentional replantation may facilitate the desired result.
- *Persistent chronic pain*: Sometimes, IR is an option as a diagnostic tool when all former treatments fail to alleviate chronic pain. It also permits evaluation of unsuspected pathosis such as resorption or fractures.

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Influence of Access Cavity Design on Root Canal Detection, Instrumentation Efficacy, and Fracture Resistance Assessed in Maxillary Molars

CrossMark

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Abstract

Introduction: The aim of this study was to assess the influence of contracted endodontic cavities (CECs) on root canal detection, instrumentation efficacy, and fracture resistance assessed in maxillary molars. Traditional endodontic cavities (TECs) were used as a reference for comparison. **Methods:** Thirty extracted intact maxillary first molars were scanned with micro–computed tomographic imaging at a resolution of 21 μm, assigned to the CEC or TEC group (n = 15/group), and accessed accordingly. Root canal detection was performed in 3 stages: (1) no magnification, (2) under an operating microscope (OM), and (3) under an OM and ultrasonic troughing. After root canal preparation with Reciproc instruments (VDW GmbH, Munich, Germany), the specimens were scanned again. The noninstrumented canal area, hard tissue debris accumulation, canal transportation, and centering ratio were analyzed. After root canal filling and cavity restoration, the sample was submitted to the fracture resistance test. Data were analyzed using the Fisher exact, Shapiro-Wilk, and t tests (α = 0.05). **Results:** It was possible to locate more root canals in the TEC group in stages 1 and 2 (P < .05), whereas no differences were observed after stage 3 (P > .05). The percentage of noninstrumented canal areas did not differ significantly between the CEC (25.8% ± 9.7%) and TEC (27.4% ± 8.5%) groups. No significant differences were observed in the percentage of accumulated hard tissue debris after preparation (CEC: 0.9% ± 0.6% and TEC: 1.3% ± 1.4%). Canal transportation was significantly higher for the CEC group in the palatal canal at 7 mm from the apical end (P < .05). Canal preparation was more centralized in the palatal canal of the TEC group at 5 and 7 mm from the apical group at 5 mm from the apical end (P < .05). There was no difference regarding fracture resistance among the CEC (996.30 ± 490.78 N) and TEC (937.55 ± 347.25 N) groups (P > .05). **Conclusions:** The current results did not show benefits associated with CECs. This access modality in maxillary molars resulted in less root canal detection when no ultrasonic troughing associated to an OM was used and did not increase fracture resistance. *(J Endod 2017;43:1657–1662)*

Key Words

Endodontic cavity, fracture resistance, instrumentation efficacy, micro–computed tomography, minimally invasive intervention

Significance

The influence of CECs on root canal preparation outcomes and fracture resistance remains limited and controversial. We provide new insights regarding root canal detection, instrumentation efficacy (noninstrumented canal area, hard tissue debris accumulation, canal transportation, and centering ratio), and fracture resistance of maxillary molars. The current results did not show benefits associated with CECs compared with TECs.

Traditional endodontic cavities (TECs) emphasize straight-line pathways into root canals to increase preparation efficacy and prevent procedural errors (1, 2). However, a concern related to TECs is the amount of tooth structure removed, which may reduce its resistance to fracture under functional loads (3, 4). As an alternative to this traditional approach, minimally invasive endodontic cavities or contracted endodontic cavities (CECs) have been described (3,5–11), emphasizing the importance of preserving the tooth structure, including pericervical dentin. It was already shown that CECs improved the fracture resistance of premolars and mandibular molars; however, this kind of access compromised the efficacy of root canal instrumentation in lower molars (8). Yuan et al (9) showed, through finite element analysis, that CECs reduced stress in the occlusal and cervical regions when performed in mandibular molars. On the other hand, another study showed that CECs were not able to improve the fracture resistance of maxillary molars when compared with TECs (10). Thus, the influence of CECs on the root canal prepa-

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Modern Concepts in Endodontic Access Preparation: A Review

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Abstract: ***The aim of every endodontic treatment is to eradicate all organic substrates from the complex root canal system and to obturate the root canal system. After the establishment of diagnosis and treatment plan, the part of the treatment directly applied to the tooth is the access cavity preparation. Access cavity preparation is of paramount importance as it is the vital stage that governs the success or ease of the subsequent treatment stages. Endodontics has seen an unparalleled advancement in technology and materials in the past couple of decades. This period has witnessed remarkable development in endodontic technologies which has brought about various modifications in all phases of endodontic treatment including access opening.***

Keywords: Access preparation, Truss access, Ninja access

1. Introduction

In this era of enhanced magnification coupled with the availability of increasingly more flexible nickel-titanium rotary instruments, there has been a paradigm shift in endodontics from conventional to conservative access preparation. Within the last 10 years, the goal of access preparation is towards reducing size of access preparation to the natural dimensions of the pulp chamber aiming at yielding improved survival outcomes. The application of traditional or conventional access cavity preparations became questionable as it is invasiveand may lead to structural failure of a tooth [1].Structural loss of tooth is one of the risk factors for fracture predilection in endodontically treated teeth [2]. Traditional access cavity preparation is found to be one of the largest causes of failure of root canal treatment. So, a reduced endodontic access design would reduce the failure of root canal treatment. Improved prognosis of root canal treated teeth is seen in conservative endodontic cavity, or ultraconservative "endodontic cavity". Clark and Khademi [3], initially proposed an approach for accessing tooth structure and dental material so as to gain access to the root canal system by leverage of caries, missing tooth structure and existing restorations.

2. Preservation of Tooth Structure

Endodontic access should be considered as the key to endodontic success, as well as restorative success and to the long-term retention of endodontically treated teeth and fracture resistance of tooth which are related to the amount of residual tooth structure [4],[5]. The long-term retention of tooth can be ensured by the preservation of the following:

2.1 Pericervical dentin (PCD)

Pericervical dentin is the dentin near the alveolar crest which is roughly 4 mm above the crestal bone and extending 4 mm apical to the crestal bone. This critical zone of dentin is irreplaceable as it plays a critical role in the maintenance of long-term survivability and optimum function of endodontically treated tooth [6].Pericervical dentin is crucial for the transfer of occlusal load to the root. Pericervical dentin preservation is of utmost importance as it helps in the prevention of fracture, preservation the ferrule.

2.2 Banking of tooth structure (Soffit)

In architecture, a soffit is described as the underside of an architectural feature such as the ceiling, the corner of the ceiling, and the wall [7].According to Clark and Khademi, a small piece of roof of pulp chamber is retained around the pulp chamber to preserve pericervical dentin, which is known as the soffit. Maintenance of soffit is a perfect example of banked tooth structure. Attempts at removing soffit which is a small piece of roof around the entire coronal portion of the pulp chamber may alsodamages the surrounding Pericervical dentin [3],[8]. The primary reason to maintain the soffit is to prevent the occurrence of the gouging of the lateral walls. This conservative approach of banking tooth structure thus aids in the long-term retention and fracture resistance of tooth.

2.3 Three-dimensional ferrule (3DF)

Ferrule is the axial wall dentin covered by the axial wall of the crown and has been described as the backbone of prosthetic dentistry. Three-dimensional ferrule is an

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Endolight Concept: A Minimally Invasive Endodontic future

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Abstract:
Minimally invasive or the endolight concepts reviews traditional endodontics and modifies it to cater to maximum preservation of the existing structures. Treatment starts with a proper diagnosis treatment planning and meticulous execution of the principles mentioned in the articlefor successful outcomes. This requires not only a thorough knowledge of the dental anatomy but also clinical expertise and upgradation of knowledge about recent advancements in the field. This article reviews strategies involved in this aspect and protocols that aid in attainment of favorable results for the longevity of treatments underwent by the patient. For this review all relevant textbooks and bibliographies of important articles and data bases from Medline, PubMed were scrutinized.

Key Word**: **Endolight concept, Pericervical Dentin, Ninja access, Calla lilly, Dynamic access

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I. Introduction

Endodontics is best described by American Association of Endodontists (AAE) as that branch of dentistry that is concerned with the morphology, physiology and pathology of the human dental pulp and peri radicular tissues. Its study encompasses the basic clinical sciences including biology of the normal pulp: the etiology, diagnosis, prevention and treatment of diseases and injuries of the pulp and association peri radicular conditions.1 And Minimally invasive endodontics (MIE) or endolight is a concept of maximum preservation of the healthy coronal, cervical and radicular tooth structure during the endodontic treatment. Thus, as I B Bender quoted "The pulp is a small tissue with a big issue"[1].

The actual inflammatory status of the pulp is not taken into consideration by treatment strategies currently. Root canal treatment is the therapy of choice to save the toothin the majority of cases of mature teeth diagnosed with irreversible pulpitis or apical periodontitis. Alternative strategies could be used to treat pulpitis and increase the success of endodontic procedures beyond the improvement of the 'tools and gadgets' used during conventional root canal treatmentwhich are less invasive. MIE channels the treatment in restoration of pulpally involved tooth aiming at the its reparative potential. Consequently, there is loss of dental hard tissue and subsequent weakening of the treated tooth as reviewed by Kishen and Al- Omiri, increasing their fracture potentialas studied by Reeh et al.[2].

Pulp dentinal complex: an underestimated factor:

The complex functions as an exquisiteresponse sensory system with unusual mechanisms to defend it from insults. Thorough understanding of this complex simplifies the treatment protocol. Studies by Pashley et al. using I ^{131} demonstrated the role of dentinal tubules in pulpal pathogenesis. Initial stimulation or irritation of odontoblasts lead to subsequent inflammation, tissue destruction and ultimately some amount of repair. Structural aspects of dentin have to be revised for a better understanding of these processes.

Dentin sub structure: The response of the underlying pulp is determined by two properties of dentin- its permeability and its sensitivity. Dentin substructure is penetrated by millions of tubules and their density varies from 40,000 to 70,000 tubules per square millimeter. The diameter of which varies from 1μm at the DEJ to 3μm at the pulpal surface. The variations in size and surface area covered by tubules are important in the pathogenesis of pulpal inflammation. The degree of pulpal damage increases exponentially with permeability. Dentin sensitivity is determined by odontoblastic processes, tubular fluid dynamics and sensory innervation.

Pulpal reactions: Pulpal immune response involves humoral and cellular challenges to invading pathogens. The host immune response increases in intensity as infection advances. Odontoblasts and dendritic cells play a pivotal role in immunologic responses. Objective clinical findings are needed for determining the

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The Effects of Endodontic Access Cavity Preparation Design on the Fracture Strength of Endodontically Treated Teeth: Traditional Versus Conservative Preparation

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Abstract

Introduction: The aim of this study was to compare the fracture strengths of mandibular molar teeth prepared using traditional endodontic cavity (TEC) and conservative endodontic cavity (CEC) methods and restored using SDR (Dentsply Caulk, Milford, DE) and EverX Posterior (GC Dental, Tokyo, Japan) base composite materials. **Methods:** A hundred mandibular first molar teeth were randomly divided into 5 groups. In group 1 (the control group), samples were kept intact. In group 2, TECs were prepared, and the samples were restored with EverX Posterior and composite resin. In group 3, CECs were prepared, and the samples were restored with EverX Posterior and composite resin. In group 4, TECs were prepared, and the samples were restored with SDR and composite resin. In group 5, CECs were prepared, and the samples were restored with SDR and composite resin. This load was applied on the samples at 1-mm/min speed using a 6-mm round-head tip until fracture. The forces resulting in fracture were recorded in newton units. The data were analyzed using Kruskal-Wallis and Pearson correlation tests at a 5% significance level. **Results:** The fracture strengths of the samples in the control group were significantly higher than the experimental groups ($P < .05$). There was no statistically significant difference in the endodontic access cavities prepared used the TEC and CEC methods and restored using the same composite base material ($P > .05$). **Conclusions:** CEC preparation did not increase the fracture strength of teeth with class II cavities compared with TEC preparation. The fracture strength of teeth restored with the SDR bulk-fill composite was higher than that of teeth restored with EverX Posterior. *(J Endod 2018;44:800–805)*

Key Words

Conservative access cavity, EverX Posterior, fracture strength, SDR, traditional access cavity

Significance

Conservative endodontic cavity preparation was proposed to reduce fracture risk of endodontically treated teeth. Conservative and traditional endodontic cavity preparation showed similar fracture strength, which was lower than the intact teeth.

The structural, esthetic, and functional rehabilitation of endodontically treated teeth is very difficult (1). Previous studies showed that by critically reducing the amount of dentin, endodontic access cavity preparation decreased the fracture strength of teeth and increased cuspal deflection during function (2–4). In traditional endodontic cavity (TEC) preparation, the controlled removal of the tooth structure is supported to prevent complications that can occur during endodontic treatment (5, 6). The loss of dentin and anatomic structures, such as cusps, ridges, and the pulp chamber roof, can result in fracture of the tooth after the final restoration (7). In contrast to TEC preparation, conservative endodontic cavity (CEC) preparation is a minimally invasive procedure that can preserve tooth structures, such as pericervical dentin (7–14). There are no exact rules to prepare the CEC; the aim is to preserve as much of the tooth structure as possible and to locate the canal orifices. In the present study, CECs were prepared considering a tooth with a mesial cavity.

Advancements in adhesive technology have enabled conservative and esthetic post-endodontic restoration (15). Conventional composites and flowable bulk-fill base composites, which can be bulk filled in layers up to 4 mm in thickness, are a good alternative for the restoration of endodontically treated posterior teeth (16). A well-known example of bulk-fill base composites is SDR (Dentsply Caulk, Milford, DE). SDR has an increased depth of cure because of increased translucency (17). SDR includes a flexible polymer that does not translate the shrinkage stress to the tooth. Thus, it is hypothesized that this will reduce the strengthening effect of the composite on the tooth.

New composite resin–based materials, including polyethylene and glass fibers, are also available for use in endodontic restoration (18). The use of newly developed fiber-based composites means that wide cavities exposed to a high level of stress, especially those in posterior teeth, can be more successfully restored (19). EverX Posterior (GC Dental, Tokyo, Japan) has been introduced for dentin replacement in large, deep, and

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0099-2399/$ - see front matter

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Modern Molar Endodontic Access and Directed Dentin Conservation

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KEYWORDS

• Molar • Endodontic • Access • Dentin

During patient treatment, the clinician needs to consider many factors that will affect the ultimate outcome. In simple terms, these factors can be grouped into 3 categories: the operator needs, the restoration needs, and the tooth needs. The operator needs are the conditions the clinician needs to treat the tooth. The restoration needs are the prep dimensions and tooth conditions for optimal strength and longevity. The tooth needs are the biologic and structural limitations for a treated tooth to remain predictably functional. This article discusses molar access and failures of endodontically treated teeth that occur not because of chronic or acute apical lesions but because of structural compromises to the teeth that ultimately renders them useless. What both authors have discovered in their respective practices through careful observations of failing cases and modes of failure, and observation of the truly long-term (decades) successful cases, is that the current models of endodontic treatment do not lead to long-term success. The authors want to coronally shift the focus to the cervical area of the tooth and create awareness for an endorestorative interface. This article introduces a set of criteria that will guide the clinician in treatment decisions to maintain optimal functionality of the tooth and help in deciding whether the treatment prognosis is poor and alternatives should be considered. This article is not an update on traditional endodontic access, as the authors believe the traditional approach to endodontic access is fundamentally flawed. Traditional endodontic access has been endodontic centric, primarily focused on operator needs, and has been decoupled from the restorative needs and tooth needs. Central to our philosophy is that balance needs to be restored to these 3 needs, which are almost always in conflict when performing complete cusp-tip to root-tip treatment.

Disclosure: Drs Clark and Khademi will receive a royalty from the sales of CK Endodontic Access burs. http://www.sswhiteburs.com.

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Dent Clin N Am 54 (2010) 249–273

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Case Studies in Modern Molar Endodontic Access and Directed Dentin Conservation

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KEYWORDS

• Maxillary • Composite • Pulp horn • Molar

The following case studies provide insight into the integration of the principles set forward in the preceding article. Each case is evaluated first on the endorestorative principles that form the basis of the modern endo-endorestorative–prosthodontic continuum. Endorestorative needs should, whenever possible, trump previous notions of endodontic needs.

Case 1 is provided by Dr Clark, and cases 2 to 6 are provided by Dr Khademi. Dr Clark's provides a stark contrast between the old and new models of endodontic access and shaping. Dr Clark then risks avoiding postplacement but also avoids the mutilating effects of a full crown by instead providing a minimally invasive restorative technique using direct composite to permanently splint the tooth for ideal function.

Case 2 shows the possibilities in a maxillary molar when an emphasis is made on banking of coronal and pericervical dentin (PCD). The conscientious preservation of tooth structure during access and endodontic shaping allows a second, and possibly third, prosthesis (crown) during the patient's lifetime.

Case 3 is an ideal study of the realities of day to day endodontic access. This thought provoking access teaches that the authors are not accessing a crown, but accessing the root through the crown. This tipped and rotated maxillary molar; is also mutilated and coronally altered with a PFM crown creating a mirage that could easily lead to gouging and even perforation unless the operator follows the disciplined approach outlined in the text.

Case 4 is an access through another PFM crown. The importance of proper accessing through full crowns should not be underestimated, as the pulpal death rate from a full crown procedure has been documented in some studies to be well over 20%.

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17. AlovisiM, PasqualiniD, MussoE, BobbioE, GiulianoC, MancinoD, et al. Influence of Contracted Endodontic Access on Root Canal Geometry : An In Vitro Study. J Endod. 2018;44(4):614–20.

Influence of Contracted Endodontic Access on Root Canal Geometry: An *In Vitro* Study

Mario Alovisi, DDS, PhD, Damiano Pasqualini, DDS,* Edoardo Musso, DDS,* Elena Bobbio, DDS,* Carlotta Giuliano, DDS,* Davide Mancino, DDS,† Nicola Scotti, DDS, PhD,* and Elio Berutti, MD, DDS**

Abstract

Introduction: Contracted endodontic cavities (CECs) have developed from the concept of minimally invasive dentistry and provide an alternative to traditional endodontic cavities (TECs). They have been designed in an effort to preserve the mechanical stability of teeth. The contracted cavity design preserves more of the dentin but may influence the geometric shaping parameters. The aim of this micro–computed tomographic study was to evaluate the influence of contracted endodontic cavities on the preservation of the original root canal anatomy after shaping with nickel-titanium rotary instruments. **Methods:** Thirty extracted human mandibular molars with fully formed apices and independent mesial canals were randomly assigned to group 1 (TEC) and group 2 (CEC). Each group was shaped using ProGlider (Dentsply Maillefer, Ballaigues, Switzerland) and WaveOne Gold (Dentsply Maillefer). Irrigation was performed with 10% EDTA and 5% sodium hypochlorite. Samples were scanned before and after canal shaping to match canal volumes (SkyScan; Bruker microCT, Kontich, Belgium [100 kV, 100 μA, and 15-μm resolution]), and images were analyzed to evaluate canal volumes, surface areas, and centroid shift on cross sections at −1 mm and −3 mm from the apex. **Results:** TECs showed a greater preservation of the original root canal anatomy with less apical transportation than CECs, possibly because of the absence of coronal interferences and, therefore, fewer pecking motions required to complete instrumentation. **Conclusions:** Within the limitations of this study, TECs may lead to a better preservation of the original canal anatomy during shaping compared with CECs, particularly at the apical level. *(J Endod 2018;44:614–620)*

Key Words

Centering ability, contracted endodontic access, micro–computed tomography, minimally invasive, nickel-titanium instruments, shaping outcomes

Significance

The influence of contracted endodontic access on root canal anatomy preservation after shaping with NiTi instruments was evaluated. The use of the traditional endodontic access during clinical practice may lead to less canal transportation at the apical level.

Access cavity preparation is considered a fundamental step in orthograde endodontic treatment (1). Complete removal of the pulp chamber roof is crucial to avoid bacterial contamination from pulp residues (2, 3). Moreover, an appropriate access may promote canal detection and enhance instrumentation efficacy by avoiding coronal interferences (4). Contracted endodontic cavities (CECs) have stemmed from the concept of minimally invasive dentistry (5, 6). They have been presented as an alternative to traditional endodontic access cavities (TECs) designed to preserve the mechanical stability of the tooth (7, 8). However, although the contracted cavity design retains more dentin, it may influence the geometric shaping parameters. In contracted access cavities, coronal interference may cause endodontic instruments to work primarily on the internal surface of the root canal, resulting in root canal transportation. Recent studies have shown that root canal transportation negatively affects long-term prognosis after endodontic procedures because of excessive removal of dentin and straightening of the original root canal curvature (9–13). However, no data are available regarding the influence of contracted cavities on geometric shaping outcomes.

Micro–computed tomographic (micro-CT) imaging is considered a reliable method to assess the quality of root canal shaping through the analysis of 2-dimensional (2D) and 3-dimensional (3D) geometric shaping parameters (14–16). The aim of this micro-CT study was to evaluate the influence of CECs on the preservation of the original root canal anatomy after shaping with nickel-titanium reciprocating instruments.

Materials and Methods

Freshly extracted mandibular first permanent molars with fully formed apices were used in accordance with the local ethics committee. A sample size of 15 per group was calculated with G*Power 3.1.4 (Kiel University, Kiel, Germany) to set the study power at 80% (a large effect size equal to 1 was considered for the sample size calculated). After debridement of the root surface, specimens were immersed in a 0.01% sodium hypochlorite (NaOCl) solution at 4°C for 24 hours and then stored in saline solution. A total of 40 teeth were selected. Specimens were mounted on a custom-made support in order to perform preliminary low-resolution micro-CT scans (SkyScan 1172; Bruker microCT, Kontich, Belgium) to attain an overall outline of the root canal anatomy and to ensure inclusion criteria were met (17). A total of 450

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18. ArticleR, AccessC, PreparationsC. EC DENTAL SCIENCE Review Article Conservative Access Cavity Preparations. 2020;2(Figure 1):1–6.

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Review Article

Conservative Access Cavity Preparations

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Abstract

Introduction: In a root canal treatment, the first step that is done is endodontic access, the access cavity plays an important role in good instrumentation and delivery of irrigants during the endodontic process. If a good endodontic access cavity is lacking, then the entire procedure is compromised at some level since an effective cleaning and shaping is the most essential for the success of a root canal procedure. An inadequate endodontic access cavity makes everything difficult in the treatment starting from locating the canals to negotiation, debridement, disinfection, and later on, the obturation of the root canals. A good endodontic access cavity also helps in prevention of any iatrogenic error during root canals like perforation, ledge formation, and instrument separation.

Aim of the Work: This study aims at assessing the conservative access cavity designs and comparing them with the traditional access cavity designs.

Methodology: The review is a comprehensive research of PUBMED from the year 1994 to 2017.

Conclusion: Minimal invasive dentistry involves the use of natural tooth structure more than any artificial restoration for strength and esthetic functions. The conservative access cavity has a stepwise approach that aims at conserving the natural tooth structure. The advent of microscopes and CBCT imaging are the most important aids that help in the success of the endodontic cavity.

***Keywords:** Contracted Access Cavity; Truss Cavity Design; Ninja Access Cavity; Soffit; Pericervical Dentin*

Introduction

The recent pass in Conservative Dentistry and Endodontics has seen a new revolution which aims at preserving the natural tooth structure as far as possible and being the most conservative one can get [1]. In a root canal treatment, the first step that is done is endodontic access, the access cavity plays an important role in good instrumentation and delivery of irrigants during the endodontic process. If a good endodontic access cavity is lacking, then the entire procedure is compromised at some level since an effective cleaning and shaping is the most essential for the success of a root canal procedure [2]. An inadequate endodontic access cavity makes everything difficult in the treatment starting from locating the canals to negotiation, debridement, disinfection, and later, the obturation of the root canals. A good endodontic access cavity also helps in prevention of any iatrogenic error during root canals like perforation, ledge formation, and instrument separation [3].

Conventional endodontic access cavity

The traditional endodontic access cavity has a predetermined shape according to the type of tooth (Figure 1).

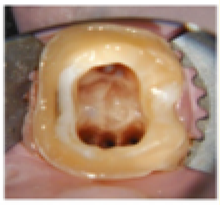

***Figure 1:** Traditional Trapezoidal shaped endodontic cavity for lower first molar [4].*

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REVIEW

Current status on minimal access cavity preparations: a critical analysis and a proposal for a universal nomenclature

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Abstract

Silva EJNL, Pinto KP, Ferreira CM, Belladonna FG, De-Deus G, Dummer PMH, Versiani MA. Current status on minimal access cavity preparations: a critical analysis and a proposal for a universal nomenclature. *International Endodontic Journal*, **53**, 1618–1635, 2020.

In the last decade, several access cavity designs involving minimal removal of tooth tissue have been described for gaining entry to pulp chambers during root canal treatment. The premise behind this concept assumes that maximum preservation of as much of the pulp chamber roof as possible during access preparation would maintain the fracture resistance of teeth following root canal treatment. However, the smaller the access cavity, the more difficult it may be to visualize and debride the pulp chamber as well as locate, shape, clean and fill the canals. At the same time, a small access cavity may increase the risk of iatrogenic complications as a result of poor visibility, which may have an impact on treatment outcome. This study aimed to critically analyse the literature on minimal access cavity preparations, propose new nomenclature based on self-explanatory abbreviations and highlight the areas in which more research is required. The search was conducted without restrictions using specifics terms and descriptors in four databases. A complementary screening of the references within the selected studies, as well as a manual search in the highest impact journals in endodontics, namely International Endodontic Journal and Journal of Endodontics, was also performed. The initial search retrieved 1831 publications. The titles and abstracts of these papers were reviewed, and the full text of 94 studies was assessed. Finally, a total of 28 studies were identified as evaluating the influence of minimally invasive access cavity designs on the fracture resistance of teeth and on the different stages of root canal treatment (orifice location, canal shaping, canal cleaning, canal filling and retreatment). Overall, the studies had major methodological drawbacks and reported inadequate and/or inconclusive results on the utility of minimally invasive access preparations. Furthermore, they offered limited scientific evidence to support the use of minimally invasive access cavities to improve the outcome of root canal treatment and retreatment; they also provided little evidence that they preserved the fracture resistance of root filled teeth to a greater extent than traditional access cavity preparations. It was concluded that at present, there is a lack of supporting evidence for the introduction of minimally invasive access cavity preparation into routine clinical practice and/or training of undergraduate and postgraduate students.

Keywords: conservative endodontic cavity, endodontics, fracture resistance, minimal access cavity preparation, minimally invasive access cavity, root canal treatment.

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Phenotypic comparison of periodontal ligament cells *in vivo* and *in vitro*

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Lekic P, Rojas J, Birek C, Tenenbaum H, McCulloch CAG: Phenotypic comparison of periodontal ligament cells in vivo *and* in vitro. *J Periodont Res 2001; 36: 71–79.* © Munksgaard, 2001.

The mammalian periodontal ligament contains heterogeneous populations of connective tissue cells, the precise function of which is poorly understood. Despite close proximity to bone and the application of high amplitude physical forces, cells in the periodontal ligament (PL) are capable of expressing regulatory factors that maintain PL width during adult life. The study of PL homeostasis and PL cell differentiation requires culture and phenotypic methods for precise characterization of PL cell populations, in particular those cells with an inherently osteogenic program. Currently it is unknown if cells cultured from the PL are phenotypically similar to the parental cells that are present in the tissues. We have compared the phenotype of cells *in vivo* with cells derived from the PL and expanded *in vitro* to assess the general validity of *in vitro* models for the study of phenotypic regulation *in vivo*. Rat PL cells were isolated by either scraping the root of the extracted first mandibular molars (Group A), or by scraping the alveolar socket following extraction of first mandibular molars (Group B), or by obtaining a mixture of cells after disaggregating a block of tissue consisting of first mandibular molar, PL and the surrounding alveolar bone (Group C). Cultured cells at confluence were fixed and immunostained for α-smooth muscle actin (α-SMA), osteopontin (OPN), alkaline phosphatase (AP), or bone sialoprotein (BSP). For *in vivo* assessments, frontal sections of rat first mandibular molar were immunostained for α-SMA, OPN, AP and BSP. We examined osteogenic differentiation of cultured PL cell cultures by bone nodule-forming assays. *In vivo* and at all examined sites, >68% of PL cells were immunostained for AP; ~50% and ~51% for OPN and α-SMA ($p=0.3$), respectively, while only ~8% were positively stained for BSP ($p<0.01$). Analysis of cultured PL cells in Groups A, B and C showed 54%, 53% and 56% positive staining for α-SMA respectively; 51%, 56%, 54% for OPN; 66%, 70%, 69% for AP and 2.2%, 1.4% and 2.8% for BSP. The mean percentage of PL cells *in situ* stained for the different markers was similar to that of cultured PL cells (Group A ~ Group B ~ Group C *in situ* for $p>0.2$) except for BSP which was 3 to 4 fold higher *in vivo* ($p<0.01$). PL cell cultures treated with dexamethasone showed mineralized tissue formation for all groups (A, B, C), but no mineralized tissue formation was detected in the absence of dexamethasone. As PL cells express quantitatively similar phenotypes *in vitro* and *in vivo*, we conclude that the *in vitro* models used here for assessment of PL cell differentiation appear to be appropriate and are independent of the cell sampling method. Further, dexamethasone-dependent progenitors are present both on the root and bone-related sides of the PL.

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Key words: phenotypic stability; periodontal ligament cells; *in vivo*; *in vitro*

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Case Report

Truss access new conservative approach on access opening of a lower molar: A case report

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ABSTRACT

This case report describes a clinical case of lower molar submitted to root canal treatment with emphasis on a new conservative approach employed in access opening. A 32-year-old female patient suffered severe sensitivity of the right lower first molar with severe attrition involving enamel and dentin as well as pulp exposition. The woman was given root canal treatment with a new conservative approach on access opening of lower molar in single visit and high strength direct composite restoration done. This technique mainly implies on the preservation of the remaining tooth apart from providing adequate disinfection, preparation, and filling of the root canal.

Keywords: Conservative approach, access opening, minimal invasive dentistry, preservation of tooth structure

Introduction

Minimal invasive dentistry is of great biological value than the artificial prosthesis. For the past few decades, the need for the conservation of tooth structure has been increasing in dentistry, especially in the preventive and restorative part of dental treatment. Carious lesions and dental fractures are usually associated with endodontic pathologies. The field of endodontics started focusing on new conservative approaches on access opening of root canal treatment. This technique mainly implies on the conservation of remaining tooth structure.

Case Report

A 27-year-old female patient was referred to a dental clinic with severe sensitivity in the right lower back tooth region. Intraoral examination revealed severe attrition of the right lower first molar [Figure 1]. Radiographic examination showed radiolucency involving enamel, dentin, and pulp [Figure 2].

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Coronal access

Following the delivery of local anesthesia and isolation with rubber dam, coronal access was made out just exactly above the mesial pulpal horn [Figure 3]. The access to pulp chamber was gained from occlusal surface to roof of the pulp chamber by orienting the bur parallel to the long axis of the tooth in oval shape buccolingually with an Endo access bur (Dentsply/Maillefer bur size no #2). Then, the bur was placed over the distal pulpal horn and the access to the pulp chamber is gained [Figure 4]. An Endo Z bur was used inside the pulp chamber at high-speed rotation creating a divergent walls in the access cavity.

Figure 1: Pre-operative clinical photograph

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Influence of Access Cavity Preparation and Remaining Tooth Substance on Fracture Strength of Endodontically Treated Teeth

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Abstract

Introduction: The purpose of this study was to assess the impact of access cavity preparation and the remaining tooth substance on the fracture strength of endodontically treated teeth. **Methods:** One hundred sound mandibular first and second molar teeth were selected and divided into 1 control and 9 test groups (n = 10/group) as follows: control group, intact teeth; group 1, teeth prepared with traditional endodontic access cavity (TEC); group 2, teeth prepared with conservative endodontic access cavity (CEC); group 3, teeth prepared with truss endodontic access cavity (TREC); group 4, TEC + 3 residual walls; group 5, CEC + 3 residual walls; group 6, TREC + 3 residual walls; group 7, TEC + 2 residual walls; group 8, CEC + 2 residual walls; and group 9, TREC + 2 residual walls. After access cavity preparation, all test teeth were endodontically treated and restored. The specimens were then loaded to fracture in a universal loading machine (Triaxial Tester T400 Digital; Controls srl, Cernusco, Italy), and fracture values were recorded in newtons. The data were analyzed with 2-way analysis of variance and Tukey post hoc analysis for multiple comparisons ($P < .05$). **Results:** Intact teeth were more resistant to fracture than the teeth in all the test groups. No statistically significant differences were found between the 3 tested access cavities ($P > .05$). Significant differences were observed between the different number of residual walls ($P < .05$). **Conclusions:** TRECs do not increase the fracture strength of endodontically treated teeth in comparison with CECs and TECs. Moreover, the loss of mesial and distal ridges reduced the fracture strength of teeth significantly. *(J Endod 2018;44:1416–1421)*

Key Words

Conservative access cavity, fracture strength, mesio-occlusal-distal cavity, residual walls, truss access cavity

Significance

The endodontic access cavity design and the loss of 1 or 2 walls reduce the fracture strength of intact teeth. The access cavity designs tested did not influence the fracture strength of treated teeth that was reduced by the loss of 2 marginal walls.

Endodontically treated teeth are more exposed than vital teeth to fracture risk during function (1–4). A large number of factors, especially the loss of dental substance, contribute to this failure (1, 5–9). Endodontic access cavity preparation could influence the quantity of the residual dental substance (10). Consequently, inspired by the minimally invasive dentistry concept (11), conservative endodontic access cavity (CEC) preparation was proposed to preserve tooth structure maximally (11, 12). The CEC technique has widely described in the literature (13–16). Some endodontists have emphasized this principle by creating "ninja" and "truss" endodontic access cavities (NECs and TRECs, respectively). An NEC consists of a small hole on the occlusal surface that should allow the clinician to find and access all of the canal orifices (16). On the other hand, a TREC consists of direct access from the occlusal surface to each canal orifice, avoiding removal of the whole pulp chamber roof (17). An NEC could compromise the complete removal of the infected pulp tissue as well as make canal shaping more difficult and less safe (16). A TREC, also called orifice-directed dentin conservation access, significantly compromised debridement of the pulp chamber of endodontically treated teeth (18).

It was reported that CEC preparation could increase the strength to fracture of endodontically treated teeth in comparison with a traditional endodontic access cavity (TEC) (7), but at the same time it could compromise instrumentation efficacy in distal canals of mandibular molars (15). Regarding the influence on the strength of endodontically treated teeth, only a previous study evaluated NECs (16), whereas no articles are actually available on TRECs.

The fracture strength of endodontically treated teeth also could be affected by insufficient residual dental substance because of caries that produce the loss of 1 or more dental walls (19, 20). Indeed, it is more clinically common to treat endodontically teeth that have lost structure for several reasons (16). Therefore, the aim of the present study was to evaluate the influence of the loss of the mesial or the mesial and distal walls in combination with TEC, CEC, and TREC preparation on the fracture strength of endodontically treated teeth.

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23. GambariniG, GalliM, MoreseA, AbduljabbarF, SeracchianiM, StefanelliLV, et al. Digital Design of Minimally Invasive Endodontic Access Cavity. 2020

applied sciences

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Article

Digital Design of Minimally Invasive Endodontic Access Cavity

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Abstract: New minimally invasive endodontic cavities have been described and proposed to preserve dentin (and enamel) through strategic access, including point endodontic access cavity (PEAC). There is no consensus to what extent PEAC contributes to tooth's resistance to fracture, because there is no agreement on how PEAC should be performed. The purpose of the present study is to describe and classify four different types of PEACs and to examine if a dynamic navigation system /DNS) could allow planning and precisely executing these cavities in vitro. Forty TrueTooth TM Replica # 3-001 models, were randomly divided into four identical groups of ten and scanned using a cone bean computed tomography (OP-Maxio 300, Instrumentarium-Kavo, Finland). Then, four different access cavities were planned and performed by using DNS (Navident dynamic navigation system, ClaroNav, Toronto, ON, Canada). For each tooth, a different PEAC was designed to obtain endodontic access to the main mesio-buccal canal (MB1), resulting in a different location of the entry point on the occlusal surface of the tooth. Precision was evaluated by comparing deviation in the inclinations between the planned and real cavity. Data were recorded and statistically analyzed. DNS allowed preparation of minimally invasive "straight line" cavities, with some differences in the accuracy.

Keywords: dynamic guide; digital planning; minimally invasive dentistry; conservative endodontic access

1. Introduction

In endodontics, the development of safer motor instruments and techniques of instrumentation associated with the support of three-dimensional assessment of dental anatomy is leading clinicians to operate in a more secure environments with enhanced predictability of outcomes: performing minimally invasive access cavities represents the goal of all these improvements [1–4].

Minimally invasive endodontics (MIE) is a clinical approach aiming at performing endodontic techniques and instrumentation, with minimal loss of tooth structure. The basic concept is to disinfect the pulp chamber, then properly clean, shape and fill the root canal systems—without sacrificing extensive occlusal enamel and dentin in the crown and roots. Several studies have shown that the

24. SilvaEJNL. Current status on minimal access cavity preparations : a critical analysis and a proposal for a universal nomenclature. 2020

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REVIEW

Current status on minimal access cavity preparations: a critical analysis and a proposal for a universal nomenclature

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Abstract

Silva EJNL, Pinto KP, Ferreira CM, Belladonna FG, De-Deus G, Dummer PMH, Versiani MA. Current status on minimal access cavity preparations: a critical analysis and a proposal for a universal nomenclature. *International Endodontic Journal*, **53**, 1618–1635, 2020.

In the last decade, several access cavity designs involving minimal removal of tooth tissue have been described for gaining entry to pulp chambers during root canal treatment. The premise behind this concept assumes that maximum preservation of as much of the pulp chamber roof as possible during access preparation would maintain the fracture resistance of teeth following root canal treatment. However, the smaller the access cavity, the more difficult it may be to visualize and debride the pulp chamber as well as locate, shape, clean and fill the canals. At the same time, a small access cavity may increase the risk of iatrogenic complications as a result of poor visibility, which may have an impact on treatment outcome. This study aimed to critically analyse the literature on minimal access cavity preparations, propose new nomenclature based on self-explanatory abbreviations and highlight the areas in which more research is required. The search was conducted without restrictions using specifics terms and descriptors in four databases. A complementary screening of the references within the selected studies, as well as a manual search in the highest impact journals in endodontics, namely International Endodontic Journal and Journal of Endodontics, was also performed. The initial search retrieved 1831 publications. The titles and abstracts of these papers were reviewed, and the full text of 94 studies was assessed. Finally, a total of 28 studies were identified as evaluating the influence of minimally invasive access cavity designs on the fracture resistance of teeth and on the different stages of root canal treatment (orifice location, canal shaping, canal cleaning, canal filling and retreatment). Overall, the studies had major methodological drawbacks and reported inadequate and/or inconclusive results on the utility of minimally invasive access preparations. Furthermore, they offered limited scientific evidence to support the use of minimally invasive access cavities to improve the outcome of root canal treatment and retreatment; they also provided little evidence that they preserved the fracture resistance of root filled teeth to a greater extent than traditional access cavity preparations. It was concluded that at present, there is a lack of supporting evidence for the introduction of minimally invasive access cavity preparation into routine clinical practice and/or training of undergraduate and postgraduate students.

Keywords: conservative endodontic cavity, endodontics, fracture resistance, minimal access cavity preparation, minimally invasive access cavity, root canal treatment.

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25. NadeauB, JungD, VoraV. Trends towards conservative endodontic treatment. 2019;

Trends towards conservative endodontic treatment

Bobby Nadeau, DDS; Dale Jung, DDS; Viraj Vora, DDS, MS

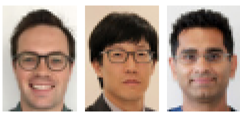
INTRODUCTION

Consider a new patient who has come to a dental office and undergoes a screening examination. A quick look at any missing teeth may prompt a dentist to ask, why were these teeth lost? While patient responses may be vague, the answer often involves fractured endodontically treated teeth (ETT). For the most part, teeth that require endodontic treatment have already undergone a prior sequence of restorative procedures, which invariably results in dentin loss and structural weakening. The addition of endodontic treatment to this sequence removes additional coronal and radicular dentin and potentially further decreases fracture resistance.[1] Dentin removal during root canal treatment (RCT) is considered an operator (modifiable) factor that could be associated with increased vertical root fracture incidence. Vertical root fractures (VRF) are defined as fractures, usually involving ETT, that are initiated exclusively in the root and ultimately lead to tooth loss.

The goal of endodontic treatment is stated as the "prevention and healing of apical periodontitis".[2] Over the last six decades, much of the endodontic research has been focused on how to successfully manage apical periodontitis (AP). The monitoring of AP progression consists of two parts: a clinical aspect that is focused around patient symptoms and a time-dependent radiographic evaluation of bone volume changes around root apices. Clinical symptoms, if present, most frequently resolve fairly quickly after RCT, however the radiographic evaluation has formed the main focus of endodontic outcomes research. These clinical studies, albeit very few in comparison to laboratory research, have inherent flaws, some of which include short observation times, uncontrollable confounding variables, low patient sample sizes and loss of patients to follow-up.[3,4] These shortcomings contribute to the difficulty many researchers have had when trying to find direct correlations between the technical aspect of RCT and radiographic 'healing' of apical periodontitis. Thus, over the years, dentists performing RCT have been forced to make clinical decisions under high levels of uncertainty.[5] While clinicians place a high value on radiographic healing of periapical tissues, this outcome measure may be meaningless to asymptomatic patients who desire long-term tooth survival.

An outcome is defined as an end result or event succeeding an action. For the most part, outcomes in dentistry can be divided into process-centered outcomes and patient-centered outcomes.[4,5] A process-centered outcome relates to the way in which the operator exercises their dexterity to satisfy the technical standards of a procedure, either non-surgical or surgical. In endodontics, many process-centered outcomes are assessed by the 'look' of the immediate post-operative radiograph.

Education and clinical practice in dentistry historically stem from the biomedical model which focuses on disease management.[6] Clinicians are often unaware of this model and how it governs their reasoning since it represents the norm that cannot be questioned.[7] Dental interventions consist of surgical procedures in the oral cavity. "Traditionally, these interventions are performed with an undivided focus on the process".[8] Consequently, dentists remain focused on technical processes, not realising how these may translate on some occasions to unfavorable patient-centered outcomes. Furthermore, research suggests that clinicians think they know what



Dr. Nadeau graduated with a DDS degree from Dalhousie University. After practicing as a general dentist in Newfoundland for one year, he enrolled in the 3-year Graduate Endodontics Program at the University of Toronto in 2016. Dr. Nadeau may be contacted at: bobby.nadeau@mail.utoronto.ca. **Dr. Dale Jung** was raised in Orange County, California. He attended Pomona College in Claremont, California and graduated with a degree in Biology. Following college, Dr. Jung spent two years at the National Institute of Dental and Craniofacial Research in Bethesda, Maryland where he studied human salivary gland development and authored or co-authored a few papers. Dr. Jung then moved back to California to attend UCLA School of Dentistry to pursue a career in dentistry. During his time in dental school, Dr. Jung became interested in the field of endodontics and following dental school, he pursued his interests at New York University College of Dentistry in New York City, New York where he earned his certification in Endodontics. **Dr. Viraj Vora** graduated from the University of Western Ontario with a DDS and a Master of Science and a Certificate of Specialty in Endodontics from the University of Michigan. Dr. Vora is in full time private practice in Vaughan, ON, limited to microscopic conservative endodontics and restorative dentistry. He may be contacted at viraj@endodonticcentre.ca.

26. BarbosaAFA, SilvaEJNL. The influence of endodontic access cavity design on the efficacy of canal instrumentation , microbial reduction , root canal filling and fracture resistance in mandibular molars. 2020;1666–79.

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The influence of endodontic access cavity design on the efficacy of canal instrumentation, microbial reduction, root canal filling and fracture resistance in mandibular molars

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Abstract

Barbosa AFA, Silva EJNL, Coelho BP, Ferreira CMA, Lima CO, Sassone LM. The influence of endodontic access cavity design on the efficacy of canal instrumentation, microbial reduction, root canal filling and fracture resistance in mandibular molars. *International Endodontic Journal*, **53**, 1666–1679, 2020.

Aim To assess the impact of conservative endodontic access cavities (CEC) and truss access cavities (TAC) during root canal treatment performed on mandibular molars in terms of: ability to shape and fill root canals, microbial reduction in canals, and cleaning of the pulp chamber. In addition, the fracture resistance of the teeth after coronal restoration was assessed. Traditional endodontic cavities (TEC) were used as a reference technique for comparison.

Methodology Thirty extracted intact mandibular molars were scanned in a microcomputed tomography device (micro-CT), matched based on similar anatomical features and assigned to TEC, CEC or TAC groups ($n = 10$). The specimens were accessed accordingly, and root canals were contaminated with bacterial suspensions of *Enterococcus faecalis* (21 days). Subsequently, the first microbial sample was collected from root canals (S1). The canals were initially prepared with Reciproc Blue R25 instrument followed by a second instrumentation using Reciproc Blue R40. Eight mL of 0.5% NaOCl were used as an irrigant for each instrument. A final irrigation protocol was performed with 2 mL of 0.5% NaOCl, 2 mL of 17% EDTA and another 2 mL of 0.5% NaOCl. Microbial samples were collected from root canals after R25 (S2), R40 (S3) and final irrigation (S4). The teeth were rescanned after S4. Then, root canals were filled, rescanned, restored and the teeth subjected to fracture resistance tests. The statistical analysis was performed with type I negative binomial and beta 0-1 inflation regression models for microbiological analysis. Instrumentation, filling and resistance to fracture results were subjected to ANOVA and Tukey tests ($P < 0.05$).

Results S4 revealed no significant variations in microbial reduction amongst the groups ($P > 0.05$). TEC had a significantly lower percentage of unprepared surface area than CEC ($P < 0.05$). No differences were found regarding the percentage of dentine removed, transportation, centring ability and filling voids amongst the groups ($P > 0.05$). The TEC group had a significantly lower volume of remaining root filling material within the pulp chamber than CEC and TAC groups ($P < 0.05$). There was no difference regarding fracture resistance amongst the groups ($P > 0.05$).

Conclusion Conservative access cavities did not offer any advantage in comparison with the traditional endodontic cavities in any of the parameters considered. Furthermore, conservative methods were associated with larger percentages of unprepared canal surface area and larger volumes of remaining root filling material within the pulp chamber.

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Impacts of Contracted Endodontic Cavities on Instrumentation Efficacy and Biomechanical Responses in Maxillary Molars

CrossMark

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Abstract

Introduction: Recently, we reported that in mandibular molars contracted endodontic cavities (CECs) improved fracture strength compared with traditional endodontic cavities (TECs) but compromised instrumentation efficacy in distal canals. This study assessed the impacts of CECs on instrumentation efficacy and axial strain responses in maxillary molars. **Methods:** Eighteen extracted intact maxillary molars were imaged with micro–computed tomographic imaging (12-μm voxel), assigned to CEC or TEC groups (n = 9/group), and accessed accordingly. Canals were instrumented (V-Taper2H; SSWhite Dental, Lakewood, NJ) with 2.5% sodium hypochlorite irrigation, reimaged, and the proportion of the modified canal wall determined. Cavities were restored with bonded composite resin (TPH-Spectra-LV; Dentsply International, York, PA). Another 28 similar molars (n = 14/group) with linear strain gauges (Showa Measuring Instruments, Tokyo, Japan) attached to mesiobuccal and palatal roots were subjected to load cycles (50–150 N) in the Instron Universal Testing machine (Instron, Canton, MA), and the axial microstrain was recorded before access and after restoration. These 28 molars and additional 11 intact molars (control) were cyclically fatigued (1 million cycles, 5–50 N, 15 Hz) and subsequently loaded to failure. Data were analyzed by the Wilcoxon rank sum and Kruskal-Wallis tests (α = 0.05). **Results:** The overall mean proportion of the modified canal wall did not differ significantly between CECs (49.7% $\pm$ 12.0%) and TECs (44.7% $\pm$ 9.0%). Relative changes in axial microstrain responses to load varied in both groups. The mean load at failure for CECs (1703 $\pm$ 558 N) did not differ significantly from TECs (1384 $\pm$ 377 N) and was significantly lower ($P < .005$) for both groups compared with intact molars (2457 $\pm$ 941 N). **Conclusions:** In maxillary molars tested *in vitro*, CECs did not impact instrumentation efficacy and biomechanical responses compared with TECs. (*J Endod 2016;42:1779–1783*)

Key Words

Endodontic cavity, fracture strength, instrumentation efficacy, minimally invasive, root strain

Significance

Fracture after endodontic treatment is an ongoing concern. Modern dentistry has seen a trend towards minimally invasive treatments. In endodontics, removal of tooth structure increases the susceptibility of teeth to fracture that gave rise to the concept of contracted cavities.

Endodontic treatment aims to retain teeth in health and function for the long-term (1), but teeth may fracture, necessitating extraction (2–4). A fracture risk factor is loss of dentin, including that associated with drilling of endodontic cavities (4). Traditional endodontic cavities (TECs) emphasize straight-line pathways into canals to enhance instrumentation efficacy and prevent procedural errors (5, 6). The associated removal of pericervical dentin (7, 8) can impact biomechanical responses of teeth (9–14). Increased cuspal flexure associated with TECs (9,12–14) may lead to increased strain at the crown and root surfaces (11–13), which, in turn, may increase the susceptibility of treated teeth to fracture under functional loads (4, 9). These biomechanical effects are undesirable, but they may be moderated in the short-term by restoration of endodontic cavities with bonded composite resin (12,15–18).

Contracted endodontic cavities (CECs), inspired by concepts of minimally invasive dentistry (19), emphasize tooth structure preservation including pericervical dentin (7, 8). We previously reported (20) that CECs, compared with TECs, improved fracture strength under a continuous load in unrestored mandibular premolars and molars but not in maxillary incisors, and compromised instrumentation efficacy in distal canals of mandibular molars but not in premolars and incisors. These results, suggesting that the impact of CECs varied in different tooth types when unrestored, might not be extrapolated to restored maxillary molars in which the morphology is distinctly different. Also, unlike available data on fracture strength of intact mandibular molars (21), respective data on maxillary molars are lacking. Therefore, this study assessed the impacts of CECs on canal instrumentation efficacy and biomechanical responses in maxillary molars

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Impacts of Conservative Endodontic Cavity on Root Canal Instrumentation Efficacy and Resistance to Fracture Assessed in Incisors, Premolars, and Molars

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Abstract

Introduction: Conservative endodontic cavity (CEC) may improve fracture resistance of teeth but compromise the instrumentation of canals. This study assessed the impacts of CEC on both variables in 3 tooth types. **Methods:** Extracted human intact maxillary incisors, mandibular premolars, and molars (n = 20/type) were imaged with micro–computed tomographic imaging (20-μm resolution) and assigned to CEC or traditional endodontic cavity (TEC) groups (n = 10/group/type). Minimal CECs were plotted on scanned images. Canals were prepared with WaveOne instruments (Dentsply Maillefer, Ballaigues, Switzerland) using 1.25% sodium hypochlorite and post-treatment micro–computed tomographic images obtained. The proportion of the untouched canal wall (UCW) and the dentin volume removed (DVR) for each tooth type was analyzed with the independent-samples t test. The 60 instrumented and 30 intact teeth (negative control, n = 10/type) were loaded to fracture in the Instron Universal Testing machine (Instron, Canton, MA) (1 mm/min), and the data were analyzed with 1-way analysis of variance and the Tukey test. **Results:** The mean proportion of UCW was significantly higher (P < .04) only in the distal canals of molars with CEC (57.2% ± 21.7%) compared with TEC (36.7% ± 17.2%). The mean DVR was significantly smaller (P < .003) for CEC than for TEC in incisors (16.09 ± 4.66 vs 23.24 ± 3.38 mm^3), premolars (8.24 ± 1.64 vs 14.59 ± 4.85 mm^3), and molars (33.37 ± 67.71 mm^3). The mean load at fracture for CEC was significantly higher (P < .05) than for TEC in premolars (586.8 ± 116.9 vs 328.4 ± 56.7 N) and molars (1586.9 ± 196.8 vs 641.7 ± 62.0 N). In both tooth types, CEC did not differ significantly from the negative controls. **Conclusions:** Although CEC was associated with the risk of compromised canal instrumentation only in the molar distal canals, it conserved coronal dentin in the 3 tooth types and conveyed a benefit of increased fracture resistance in mandibular molars and premolars. *(J Endod 2014;40:1160–1166)*

Key Words

Dentin volume removed, endodontic cavity, fracture resistance, instrumentation efficacy

Traditional endodontic cavity (TEC) designs for different tooth types have remained unchanged for decades with only minor modifications. Highlighting "convenience form" and "extension for prevention" (1), TEC promotes the controlled removal of tooth structure beyond gaining access to canal orifices to facilitate cleaning, shaping, and filling of root canals and to prevent procedural complications (1, 2). Consequent removal of tooth structure, coronal to the pulp chamber, along the chamber walls, and around canal orifices, may undermine the resistance of the tooth to fracture under functional loads (3–5). Indeed, fractures and possible subsequent extraction of root-filled teeth (6–9) have undermined the confidence of dentists and patients in the long-term benefits of endodontic treatment (5, 10).

Recently, Clark and Khademi (10, 11) modified the endodontic cavity design to minimize tooth structure removal. In departure from the completely unroofed, coronally divergent, straight-line access to canal curvatures, the conservative endodontic cavity (CEC) preserves some of the chamber roof and pericervical dentin (10). Clinically, the smallest CEC possible for each tooth can be outlined on cone-beam computed tomographic (CBCT) images (12) by plotting the trajectory toward each canal. Although the preserved tooth structure may offer a benefit of improved fracture resistance under functional loads (5), the confined CEC outline restricts cleaning, shaping, and filling of the root canals (10, 11), increasing the risks of inefficient canal instrumentation and the occurrence of procedural errors (2). Specific investigation into CEC is warranted to assess the associated risks and benefits for different tooth types.

Mechanical efficacy of canal instrumentation is routinely assessed with nondestructive micro–computed tomographic (micro-CT) imaging (13–18). Analysis of pre- and postoperative micro-CT images enables measurements of changes in root canal morphology, including volume of the dentin removed and canal wall surface areas untouched by instruments (13–18). Fracture resistance of teeth is routinely assessed by simulated functional loading in the Instron Universal Testing machine (Instron, Canton, MA) until fracture occurs (19, 20). Loading point, force, and direction can be controlled and the load at fracture recorded (19, 20).

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Preparation of Oval-shaped Root Canals in Mandibular Molars Using Nickel-Titanium Rotary Instruments: A Micro-computed Tomography Study

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Abstract

Introduction: This study evaluated the prepared surface areas of oval-shaped canals in distal roots of mandibular molars using four different instrumentation techniques. **Methods:** Teeth were prescanned and reconstructed using micro–computed tomography (MCT) scans at low resolution (68 μm). Forty-eight molars with ribbon-shaped/oval distal root canals were selected and randomly assigned to four groups. Distal canals (n = 12 each) were prepared by circumferential filing using Hedström files to apical size #40 (group H/CF); with ProTaper nickel-titanium rotaries to finishing file 4 (F4) considering the distal canal as 1 canal (group PT/1); ProTaper to F4 considering buccal and oral aspects of the distal canal as 2 individual canals (group PT/2); ProTaper to F4 in a circumferential filing motion (PT/CF). Before and after shaping, teeth were evaluated using MCT at 34-μm resolution. The percentage of prepared surface was assessed for the full canal length and the apical 4 mm. Statistical analysis was performed using analysis of variance and Bonferroni/Dunn multiple comparisons. **Results:** Preoperatively, canal anatomy was statistically similar among the groups (p = 0.56). Mean (± standard deviation) untreated areas ranged from 59.6% (±14.9, group PT/2) to 79.9% (±10.3, PT/1) for the total canal length and 65.2% to 74.7% for the apical canal portion, respectively. Canals in group PT/1 had greater untreated surface areas (p < 0.01) than groups PT/2 and PT/CF. Among all groups, amounts of treated surface areas were statistically similar in the apical 4 mm. **Conclusions:** Preparations of oval-shaped root canals in mandibular molars left a variable portion of surface area unprepared regardless of the instrumentation technique used. However, considering oval canals as two separate entities during preparation appeared to be beneficial in increasing overall prepared surface. *(J Endod 2010;36:703–707)*

Key Words

Micro–computed tomography scans, nickel-titanium instruments, oval root canals, root canal preparation

One of the major procedural steps in endodontic treatment is to thoroughly remove debris, pulp tissue, and microorganisms from the root canal system by means of chemomechanical preparation (1). To this end, it has been suggested to prepare canals to a homogenous tapered shape with the prepared canal including the preoperative outline (1, 2). However, the root canal system is anatomically complex, and mechanical instrumentation may result in preparation errors. Moreover, the use of both conventional hand files and current nickel-titanium (NiTi) rotary instruments does not result in a fully prepared root canal surface (3).

A funnel-shaped canal with a circular base is not the common configuration in root canal anatomy (2). Recently, cross-sectional root canal configurations have been classified as round, oval, long oval, flattened, or irregular (4). Metrically, Jou et al (4) defined "oval" as having a maximum diameter of up to 2 times greater than the minimum diameter and "long oval" as having a maximum diameter of 2 to 4 times greater than the minimum diameter.

A high prevalence of oval and long oval root canals even in the apical root canal portion has been reported (5–7). According to Wu et al (5), the prevalence of long-oval root canals in the apical third of human teeth is generally about 25%; in some groups of teeth such as lower incisors and upper second premolars, the prevalence is greater than 50%, and in distal roots of lower molars, the prevalence is 25% to 30%. This complex anatomy may be regarded as one of the major challenges in infection control through root canal preparation.

One aim in the preparation of infected root canals is to remove the inner layer of dentin (8). This aim is particularly hard to achieve when preparing long oval root canals. Furthermore, after preparation, uninstrumented recesses may be left in many oval canals, irrespective of the instrumentation technique, thus leaving debris and unprepared root canal surfaces behind (8–13).

Various instrumentation techniques have been recommended to facilitate the preparation of oval root canals (13). The most common technique using hand instruments is circumferential filing with K-type or Hedström files. After the introduction of rotary NiTi instruments, laboratory research on extracted teeth has also addressed their ability to shape oval root canals (12). However, in that study, rotary instruments, even if used in a circumferential filing motion, were not superior compared with hand instrumentation techniques. More recently, the use of rotary instruments with taper larger than 4% was shown to be more efficient than hand files in preparing oval root canals (14). However, the tapered NiTi instruments used in that study were unable to completely prepare oval root canal walls.

The previously mentioned studies were performed on roots of extracted teeth, which were sectioned before the preparation of the root canals. Then, root cross-sections were assessed before and after preparation, thus representing

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RESEARCH ARTICLE Open Access

Evaluation of relationship between endodontic access cavity types and secondary mesiobuccal canal detection

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Abstract

Background: The aim of this study was to evaluate the relationship between Endodontic Access Cavity (EAC) types with MB2 canal detection ratio in the upper first molars.

Methods: A total of 60 roots of extracted human maxillary first molars were selected. All teeth were prepared with Point EAC (PEAC), Conservative EAC (CEAC) and Traditional EAC (TEAC) respectively. After each group were completed, extra canal was searched. Preoperative and postoperative tooth weigh was calculated using precise scale. McNemar's chi-square test and a paired test significant difference were used for statistical analyses.

Results: The EAC types statistically were changed of tooth tissue loss quantity ($p = 0.000$). MB2 detection rate of CEAC (%53,3) and TEAC (%60) are higher than statistically that of PEAC (%31.6) ($p < 0.05$). 8 teeth MB2 canal was detected only with the CBCT images.

Conclusions: In upper molars, CEAC seems reasonable in terms of detected the MB2 canal and removed hard tissue.

Keywords: Endodontic access cavity, Second mesiobuccally canal, Upper molar, Minimal invasive therapy

Background

The fracture resistance for root canal-treated teeth is less than that of vital teeth [1]. The reason might be due to the hardness of vital dentin being more than that of endodontically dentin [2]. It was observed in previous studies that endodontic access cavity (EAC) [3] and size of its [4] are reduced to fracture resistance of tooth. Most teeth that are extracted for endodontic reasons are due to restoration causes [5]. Therefore, sound tooth tissue should be prepared as minimally invasive as possible to increase the prognosis [6].

In the upper molars, though the MB2 canal ratio depends on factors such as sex and ink [7], using various techniques and devices may affect the MB2 canal detection ratio [8]. Using an operation microscope in the root canal treatment increased the second mesiobuccal (MB2) detection ratio of the maxillary molar [9]. The MB2 may be initiated a few millimetres beneath the pulp floor [10], and specific ultrasonic devices, such as a troughing tip, were suggested for detecting such canals [11]. Minimally prepared cavities would limit the detection of the channel orifices' localisation because molar teeth, in particular, have various canal configurations [12]. Sub-pulpal groove anatomies in maxillary first molars have indicated [13] that they have mostly trapezoid (52%) rectangle (24%) and triangle (16%) forms. The location of the canal orifices may also change if the teeth have deviation and rotation [14]. Therefore, the relationship between optimum root canal treatment and minimal invasive preparation is critical.

With the development of different devices and techniques, contemporary dentistry has seen a minimally invasive approach. Point endodontic access cavities, which are known as ninja cavities [15], are opened by removing minimum substance to reach root canals [16]. Clark and Khademi [17] have suggested a preparation technique called a conservative EAC in order to remove minimal tooth tissue. It was reported [18] that teeth with conservative EAC possess greater fracture resistance than traditional EAC. In current studies, the effect of conservative access cavity on tooth resistance have been investigated

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31. VieiraGCS, AlvesRF. Impact of Contracted Endodontic Cavities on Root Canal Disinfection and Shaping. 2020;46(5):655–61.

BASIC RESEARCH – TECHNOLOGY

Impact of Contracted Endodontic Cavities on Root Canal Disinfection and Shaping

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ABSTRACT

Introduction: The impact of minimally invasive endodontic procedures on root canal disinfection has not been determined. This *ex vivo* study compared root canal disinfection and shaping in teeth with contracted or conventional endodontic cavities. **Methods:** Mandibular incisors with oval-shaped canals were selected and anatomically matched based on micro–computed tomographic (micro-CT) analysis and distributed into 2 groups. Conservative and conventional access cavities were prepared, and the canals were contaminated with a pure culture of *Enterococcus faecalis* for 30 days. Root canal preparation in both groups was performed using the XP-endo Shaper instrument (FKG Dentaire, La Chaux-de-Fonds, Switzerland) and 2.5% sodium hypochlorite irrigation. Intracanal bacteriologic samples were taken before and after preparation, and DNA was extracted and subjected to quantitative polymerase chain reaction. Micro-CT scans taken before and after preparation were used for shaping evaluation. Bacteriologic data were analyzed by the Poisson regression model and the chi-square test with Yates correction. Micro-CT data were analyzed by the Wilcoxon, Mann-Whitney, and Student *t* tests with the significance level set at 5%. **Results:** All initial samples were positive for *E. faecalis*. After preparation, the number of bacteria-positive samples was significantly higher in the contracted cavity group (25/29, 86%) than in the conventional cavity group (14/28, 50%) ($P < .01$). Intergroup quantitative comparison showed that the reduction in bacterial counts was also significantly higher in the group of conventional cavities ($P < .01$). Micro-CT data revealed no significant difference in the amount of unprepared areas between groups. **Conclusions:** Our findings showed that although shaping using an adjustable instrument was similar between groups, disinfection was significantly compromised after root canal preparation of teeth with contracted endodontic cavities. *(J Endod 2020;46:655–661.)*

SIGNIFICANCE

Preserving hard tissue during root canal treatment is a logical goal to prevent tooth fracture and loss. In this context, preparation of conservative endodontic access cavities has been proposed. Although shaping of oval canals with adjustable instruments was not significantly different between groups, disinfection was much better in teeth with conventional cavities than in teeth with contracted cavities.

KEY WORDS

Bacterial reduction; contracted endodontic cavity; endodontic treatment; minimally invasive endodontics; root canal preparation

Because apical periodontitis is an inflammatory disease caused by bacteria that colonize the root canal system, successful root canal treatment relies on effective infection control[1]. An initial and very important phase of root canal treatment is to prepare a coronal access cavity with adequate design and size to permit the detection of all root canal orifices, reducing the risks of missing canals that might jeopardize the treatment outcome[2], and enhance the efficacy of root canal instrumentation, eliminating coronal anatomic interferences and preventing intraoperative iatrogenic complications, such as ledge formation and instrument fracture[3,4].

Recently, the concept of minimally invasive endodontics (MIE) has been introduced with the main purpose of promoting minimal change to the dental hard tissues during root canal treatment in order to improve the long-term survival and function of treated teeth[5]. MIE is a natural derivative of minimally invasive dentistry, which has been claimed to include approaches to prevent or treat disease with as little loss of original tissue as possible[6]. An important aspect of MIE refers to the size and design of endodontic access cavities. Contracted cavities have been recommended to preserve hard tissue structure and reduce the risks of tooth fracture and loss after root canal treatment. Studies evaluating the influence of

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32. PlotinoG, TestarelliL. Standardization of Endodontic Access Cavities Based on 3-dimensional Quantitative Analysis of Dentin and Enamel Removed. 2020;46(10):1495–500.

BASIC RESEARCH – TECHNOLOGY

Standardization of Endodontic Access Cavities Based on 3-dimensional Quantitative Analysis of Dentin and Enamel Removed

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ABSTRACT

Introduction: The aim of this study was to determine and compare the difference in the volume of dentin and enamel removed (DER) to prepare 3 different access cavities and to propose a standardization of the access cavities according to their volume of DER. **Methods:** One hundred twenty maxillary and mandibular molars and premolars were assigned to 3 subgroups for each tooth type (n = 10): the traditional endodontic cavity (TEC) group; the conservative endodontic cavity (CEC) group with partial unroofing and convergent walls; and the ultraconservative endodontic cavity (UEC) group, preserving most part of the pulp chamber roof and the occlusal surface. The sliced image data of cone-beam computed tomographic images before and after access cavity preparation were exported as Digital Imaging and Communications in Medicine files and imported into the MeVisLab framework system (MeVis Research, Bremen, Germany). After segmentation, the volumes of coronal dentin and enamel were measured, and the difference in the percentage of volume of DER for endodontic access cavity preparation was calculated. The data were subjected to statistical analyses (analysis of variance) with a level of significance set at $P < .05$. **Results:** The percentage of volume of DER was less than 6% for the UEC group, up to 15% for the CEC group, and more than 15% for the TEC group, with a statistically significant difference among all groups in all of the tooth types analyzed ($P < .05$). **Conclusions:** The present study showed significantly different percentages of volume of DER among the groups analyzed (ie, UEC < CEC < TEC). A standardization of access cavity preparation was proposed according to the percentage of volume of DER. *(J Endod 2020;46:1495–1500.)*

KEY WORDS

Conservative access; endodontic access cavity; minimally invasive access; traditional access; ultraconservative access

SIGNIFICANCE

Minimally invasive endodontic cavities remain with no definition of volumetric changes of dentin and enamel removed. We proposed a standardization of endodontic access cavities. The current results show a significantly different percentage of volume of DER among groups (ie, UEC < CEC < TEC).

The main objective of endodontic cavity preparation is to access the pulp chamber and aid in cleaning, shaping, and filling the root canal system while avoiding excessive removal of the sound tooth structure[1,2]. However, the preparation of a traditional endodontic cavity (TEC) requires the removal of an important amount of enamel and dentin, which may lead to weakened resistance under functional loads[3,4]. In fact, a TEC aims to perform complete unroofing of the pulp chamber, exposure of all the pulp horns, and a straight-line access to the root canals with coronally divergent walls without undercuts to visualize the pulp chamber floor and all the root canal orifices from the same visual angulation.

The conservative endodontic cavity (CEC) was proposed to preserve part of the pulp chamber roof and the pericervical dentin (4 mm above and apical to the cementoenamel junction), aiming to improve the fracture resistance of endodontically treated teeth[5–7]. A CEC aims to perform partial unroofing of the pulp chamber with preservation of the pulp horns and a slightly convergent wall occlusally beveled to visualize the pulp chamber floor and all the root canal orifices from different visual angulations[8]. On the other hand, ultraconservative endodontic cavity (UEC) teeth are accessed similarly to teeth with a CEC[8] to perform an access cavity just to locate the orifices with extreme unroofing of the pulp chamber,

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Fracture Strength of Endodontically Treated Teeth with Different Access Cavity Designs

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Abstract

Introduction: The purpose of this study was to compare *in vitro* the fracture strength of root-filled and restored teeth with traditional endodontic cavity (TEC), conservative endodontic cavity (CEC), or ultraconservative "ninja" endodontic cavity (NEC) access. **Methods:** Extracted human intact maxillary and mandibular premolars and molars were selected and assigned to control (intact teeth), TEC, CEC, or NEC groups (n = 10/group/type). Teeth in the TEC group were prepared following the principles of traditional endodontic cavities. Minimal CECs and NECs were plotted on cone-beam computed tomographic images. Then, teeth were endodontically treated and restored. The 160 specimens were then loaded to fracture in a mechanical material testing machine (LR30 K; Lloyd Instruments Ltd, Fareham, UK). The maximum load at fracture and fracture pattern (restorable or unrestorable) were recorded. Fracture loads were compared statistically, and the data were examined with analysis of variance and the Student-Newman-Keuls test for multiple comparisons. **Results:** The mean load at fracture for TEC was significantly lower than the one for the CEC, NEC, and control groups for all types of teeth ($P < .05$), whereas no difference was observed among CEC, NEC, and intact teeth ($P > .05$). Unrestorable fractures were significantly more frequent in the TEC, CEC, and NEC groups than in the control group in each tooth type ($P < .05$). **Conclusions:** Teeth with TEC access showed lower fracture strength than the ones prepared with CEC or NEC. Ultraconservative "ninja" endodontic cavity access did not increase the fracture strength of teeth compared with the ones prepared with CEC. Intact teeth showed more restorable fractures than all the prepared ones. *(J Endod 2017;43:995–1000)*

Key Words

Conservative access cavity, endodontic access cavity, fracture resistance, "ninja" cavity, traditional endodontic cavity

Significance

CEC and NEC access was proposed to reduce fracture risk of endodontically treated teeth. Teeth with CEC and NEC showed similar fracture strength, which was higher than that of teeth with traditional endodontic access.

One of the most important steps for successful endodontic treatment is access cavity preparation. The traditional endodontic cavity (TEC) design for different tooth types has remained unchanged for decades, and only minor modifications have been done (1). However, the removal of tooth structure needed for access cavity preparation may undermine the strength of the tooth to fracture under functional loads (2, 3). Extraction is the most frequent consequence of fracture of endodontically treated teeth (4–6). Extended preparation of endodontic access cavities critically reduces the amount of sound dentin (7–10) and increases the deformability of the tooth (8), compromising the strength to fracture of endodontically treated teeth (7).

Recently, conservative endodontic cavity (CEC) preparation (11, 12) to minimize tooth structure removal and preserve some of the chamber roof and pericervical dentin was reported in the literature. This sound dentin preservation could be achieved with the help of cone-beam computed tomographic (CBCT) imaging to identify all the canals (13, 14). This could improve the fracture strength of endodontically treated teeth (11).

Following this concept, an extreme conservative approach has recently been proposed, which is conventionally known as "ninja." This technique may improve the fracture strength of endodontically treated teeth (15). To date, there are no studies comparing CEC access cavity preparation with ultraconservative "ninja" endodontic cavity (NEC) access. Therefore, the purpose of this study was to investigate the fracture strength of endodontically treated teeth with a TEC, CEC, or NEC access cavity.

Materials and Methods

Specimen Selection and Preparation

After ethics approval, 160 recently extracted intact human maxillary and mandibular molars and premolars from a white population with completely formed apices were used. The exclusion criteria for the tested teeth were the presence of caries, previous restoration, and visible fracture lines or cracks.

After a debridement with hand scaling instruments and cleansing with a rubber cup and pumice, the teeth were stored in individually numbered containers with 0.1% thymol solution at 4°C until used and during all the time between the different phases of the experiment in order to prevent their dehydration.

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State of the Art of Micro-CT Applications in Dental Research

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Abstract

Michael V. Swain, Jing Xue. State of the Art of Micro-CT Applications in Dental Research. *International Journal of Oral Science*, 1(4): 177–188, 2009

This review highlights the recent advances in X-ray microcomputed tomography (Micro-CT) applied in dental research. It summarizes Micro-CT applications in measurement of enamel thickness, root canal morphology, evaluation of root canal preparation, craniofacial skeletal structure, micro finite element modeling, dental tissue engineering, mineral density of dental hard tissues and about dental implants. Details of studies in each of these areas are highlighted along with the advantages of Micro-CT, and finally a summary of the future applications of Micro-CT in dental research is given.

Keywords X-ray microcomputed tomography (Micro-CT), dentistry, dental application

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Introduction

Since the invention of X-rays by Roentgen in 1895, technology has led to a revolution in diagnostic medicine, making it possible to see the inner workings of the body non-invasively (Dunn, 2001). X-ray computed tomography (CT) imaging was first developed in the early 1970s. Since then advanced diagnostic imaging technologies have revolutionized the practice of medicine. Images collected from multiple viewing angles are reconstructed to produce three-dimensional (3D) spatial distribution maps of material density within attenuating materials or tissues such as teeth (Hounsfield, 1973). By comparison, conventional radiography was limited to providing two-dimensional (2D) images that represent the summation of material attenuation along the X-ray path. While clinical CT scanners typically produce images composed of 1 mm^3 volume elements (voxels), X-ray microcomputed tomography (Micro-CT or μCT) systems developed in the early 1980s had times smaller in volume than CT voxels (Feldkamp *et al.*, 1989; Kuhn *et al.*, 1990). Early Micro-CT scanners were custom-built and not widely available. Compact commercial systems are now available and are rapidly becoming essential components of many academic and industrial research laboratories. A wide range of specimens may be examined directly using Micro-CT including mineralized tissues such as teeth, bone, and materials such as ceramics, polymers, biomaterial scaffolds *etc*. Micro-CT imaging could also be extended to soft tissues such as lungs that have been infiltrated or perfused with a contrast agent having a higher density than the surrounding tissue. With the development of Micro-CT systems, the newest generation of such systems allows for *in vivo* imaging of small live animals (Guldberg *et al.*, 2003; Guldberg *et al.*, 2004).

Micro-CT system using microfocal spot X-ray sources and high resolution detectors, allow for projections rotated through multiple viewing directions to produce 3D reconstructed images of samples.

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State of the Art of Micro-CT Applications in Dental Research

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Abstract

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Micro-CT system using microfocal spot X-ray sources and high resolution detectors, allow for projections rotated through multiple viewing direc-

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Fracture resistance of posterior teeth restored with modern restorative materials

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Abstract

We studied the fracture resistance of maxillary premolars restored with recent restorative materials. Fifty maxillary premolars were divided into five groups: Group 1 were unprepared teeth; Group 2 were teeth prepared without restoration; Group 3 were teeth restored with tetric ceram HB; Group 4 were teeth restored with InTen S; and Group 5 were teeth restored with Admira. The samples were tested using a universal testing machine. Peak loads at fracture were recorded. The teeth restored with Admira had the highest fracture resistance followed by those restored with InTen-S and tetric ceram HB. Prepared, unrestored teeth were the weakest group. There was a significant difference between the fracture resistance of intact teeth and the prepared, unrestored teeth. There was also a significant difference among the tested restorative materials. Teeth restored with Admira showed no significant difference when compared with the unprepared teeth. It was concluded that the teeth restored with Admira exhibited the highest fracture resistance.

Keywords: fracture resistance, composite resin, adhesives, mesio-occlusal-distal (MOD) cavities

INTRODUCTION

Removal of tooth structure *via* cavity preparation has been shown to weaken teeth and increase their susceptibility to fracture[1,2]. Studies on the weakening of teeth by mesio-occlusal-distal (MOD) cavity preparations and the effect of restorations in strengthening the remnant tissue have been conducted experimentally[3-5]. Furthermore, even if fracture does not occur, deflection of a weakened cusp may open the tooth-restoration interface and lead to microleakage resulting in recurrent caries[6]. Depending on the extent of the cavity, restorative treatment is a predisposing factor for an incomplete or complete tooth fracture[7,8].

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Stress concentrates at the internal line angles of the prepared cavity when restorations are not bonded to the tooth and at the dentine-enamel junction for bonded restorations. Therefore, fatigue failure could occur as a result of the masticatory process if the level of stress in these areas was sufficient to initiate crack propagation[9]. Cavity preparation and endodontic treatment can cause higher stress concentration in dentin, compared with vital teeth, but proper restoration can minimize internal stresses[10].

Stabilization (strengthening) of the tooth after an intracoronal preparation can be achieved by covering the outer surface with a cast metal onlay (external splinting). However, this procedure involves additional loss of healthy dental hard tissue[11]. An alternative method to external splinting is the adhesive technique, i.e., "internal splinting or restoration", which

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Comparison of Efficacy of Pulverization and Sterile Paper Point Techniques for Sampling Root Canals

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Abstract

Introduction: The purpose of this study was to compare the efficacy of the pulverization and sterile paper point techniques for sampling root canals using 5.25% NaOCl/17% EDTA and 1.3% NaOCl/MTAD (Dentsply, Tulsa, OK) as irrigation regimens. **Methods:** Single-canal extracted human teeth were decoronated and infected with *Enterococcus faecalis*. Roots were randomly assigned to 2 irrigation regimens: group A with 5.25% NaOCl/17% EDTA (n = 30) and group B with 1.3% NaOCl/MTAD (n = 30). After chemomechanical debridement, bacterial samplings were taken using sterile paper points and pulverized powder of the apical 5 mm root ends. **Results:** The sterile paper point technique did not show growth in any samples. The pulverization technique showed growth in 24 of the 60 samples. The Fisher exact test showed significant differences between sampling techniques (P < .001). The sterile paper point technique showed no difference between irrigation regimens. However, 17 of the 30 roots in group A and 7 of the 30 roots in group B resulted in growth as detected by pulverization technique. Data showed a significant difference between irrigation regimens (P = .03) in pulverization technique. **Conclusions:** The pulverization technique was more efficacious in detecting viable bacteria. Furthermore, this technique showed that 1.3% NaOCl/MTAD regimen was more effective in disinfecting root canals. *(J Endod 2013;39:1057–1059)*

Key Words

EDTA, MTAD, NaOCl, paper points, pulverization, sampling

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The normal root canal anatomy is complex because of the presence of numerous ramifications, irregularities, and dentinal tubules located distant from the main canal (1). These anatomic complexities create challenges for thorough disinfection (2). These complexities also raised concerns regarding using sterile paper points to sample root canals because they lack the sensitivity to detect bacteria in the complex root canal system (3). As a result, this method may produce false-negative results, thereby misrepresenting the true extent of infection of the root canal system.

The pulverization technique has been suggested as an alternative for sampling root canals (4–6). The advantage of this technique is to obtain a more representative bacterial sample. Determining a more sensitive root canal sampling technique is imperative to facilitate the evaluation of the antibacterial efficacy of an irrigant.

Sodium hypochlorite (NaOCl) is most commonly used as a root canal irrigant because of its antibacterial effect and tissue-dissolving ability (7–9). Final rinse solutions such as EDTA or BioPure MTAD (Dentsply, Tulsa, OK) are recommended to remove the smear layer during chemomechanical debridement (10, 11). The investigation of antibacterial properties of 5.25% NaOCl/EDTA and 1.3% NaOCl/MTAD irrigation regimens has shown inconsistent results (12–14). It is possible that the poor sensitivity of different root canal sampling techniques performed in previous studies contributed to the inconsistent results. Although the sensitivity of the sterile paper point technique has been questioned and the potential sensitivity of pulverization technique is encouraging, there are no published studies that directly compare the efficacy of both techniques. The purpose of this study was to compare the efficacy of pulverization and sterile paper point techniques for sampling root canals using 5.25% NaOCl/17% EDTA and 1.3% NaOCl/MTAD as irrigation regimens.

Materials and Methods

Seventy extracted human teeth with mature apices were stored in saline, radiographed to confirm the presence of a single canal, and decoronated at the cementoenamel junction. Pulp tissues were removed with a barbed broach, and patency was confirmed with a #10 K-file.

A customized model was assembled for each root by expressing polyvinyl siloxane impression material (Reprosil Heavy Body; Dentsply/Caulk, Tulsa, OK) into 2-inch segments of surgical tubing (1/4-inch diameter). Roots were embedded in impression material and removed when the material was set. The roots and customized models were separately steam autoclaved at 121°C for 30 minutes. Autoclaved roots were placed into a sterile 250-mL flask filled with sterile brain-heart infusion (BHI) broth, incubated for 48 hours at 37°C, and examined for turbidity.

From this point, the aseptic technique was used, including sterile surgical gloves and a class II (type A2) biohazard laminar flow cabinet (NuAire, Plymouth, MN). All roots were inoculated with *Enterococcus faecalis* (American Type Culture Collection 19433) and incubated for 4 weeks under aerobic conditions at 37°C. The media was replenished every 7 days. When replacing the media, random samples from the root canals were cultured to confirm the growth of *E. faecalis*. Colonies of *E. faecalis* in pure culture were detected as white pinpoint colonies on agar media and examined

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CLINICAL ARTICLES

Operating Microscope Improves Negotiation of Second Mesiobuccal Canals in Maxillary Molars

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This in vitro study investigated the prevalence, location, and pathway of the second mesiobuccal canal (MB-2) in 45 first and second maxillary molars using the operating microscope (OM). Initially location and negotiation of MB-2 were attempted without magnification. Teeth in which MB-2 was not located or could not be negotiated were further explored under OM. Roots where MB-2 could not be negotiated even with OM were cross-sectioned and inspected microscopically. Morphometric measurements were performed to map the location of MB-2. Without magnification an apparent MB-2 orifice was located in 42 teeth and the canal negotiated in 31 (69%). With OM one additional apparent MB-2 orifice was located, and five previously identified canals were negotiated (total 80%). The root cross-sections confirmed the absence of MB-2 in all nine teeth where it was not negotiated. Location of MB-2 varied randomly. In conclusion MB-2 can be negotiated in 80% of maxillary molars, although an orifice is apparent in 96% of the teeth. Ability to negotiate MB-2 is facilitated by OM.

The morphology of the root canal system in the mesiobuccal root of maxillary molars has attracted the attention of researchers and clinicians for the past 75 yr (1–19). Many studies have focused on the prevalence of a second mesiobuccal (MB-2) canal, which has been investigated with a variety of methods. In vitro root sections (1, 3, 7, 9, 11, 15, 18), radiographs (2, 6, 9, 16), and clearing (5, 12, 16, 17) have demonstrated the presence of MB-2 canals in 52 to 96% of the teeth. Clinically MB-2 canals have been found less frequently, from 16% (8) to 78% (13). The prevalence of MB-2 canals in second molars has been shown to be quite similar to that of first molars (5, 11) or up to 28% lower (4, 12, 17, 19). The MB-2 canal can terminate in an independent foramen, classified as type III (1), in 10% (4) to 71% (17) of the teeth. Otherwise it can be rudimentary, classified as type IV (6), or merge with the main mesiobuccal canal, classified as type II (1).

Within the wide range of reported prevalence of MB-2 canals, a clear increase in prevalence may be observed in the most recent studies (10–19). This is particularly evident in the clinical (10, 13, 14, 19) and clinical simulation (11, 16–18) studies, in which MB-2 canals were found in more than 71% of the teeth. This considerable increase has been attributed mainly to improved awareness of the presence of MB-2 canals (17, 19). In addition the shape of the access cavity in maxillary molars has been modified to facilitate the location of MB-2 canals (4, 8), and new instruments, particularly ultrasonic troughing tips (13, 19), have been used. Nevertheless MB-2 canals frequently elude clinicians.

In recent years the operating microscope (OM) was introduced to endodontics and has significantly improved magnification and illumination. Because the OM has become more widely used in nonsurgical treatment procedures (20), clinicians have indicated that it facilitates treatment of very fine canals, particularly the MB-2 canal (19). One clinical simulation study (18) demonstrated an increase in the number of MB-2 canals located from 51% without the use of OM, to 82% with OM.

The purposes of this in vitro study of maxillary molars were to: (i) compare the ability of endodontists to locate and negotiate MB-2 canals in maxillary molars without magnification and with the OM; and (ii) characterize the MB-2 canal with regard to prevalence, location, pathway, and negotiability.

MATERIALS AND METHODS

A mixed population of 45 extracted human maxillary first and second molars was used. There was no information available regarding the causes and time of extraction of these teeth. Before use the teeth were stored in 1% thymol solution for 1 wk, then divided into three equal groups, and mounted in dentoforms. Each group was operated on independently by one of three endodontists.

Conventional, extensive access cavities were completed in all teeth without magnification. Slow-speed Mueller burs (Brasseler, Savannah, GA) and SP-1 ultrasonic tips (Analytic Technology, Orange, CA) were then used to uncover the MB-2 canal orifice. Dentin was selectively removed from the pulp chamber floor and at the mesial-axial line angle of the cavity, along the mesiobuccal

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RESEARCH ARTICLE

Microbiome in the Apical Root Canal System of Teeth with Post-Treatment Apical Periodontitis

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Abstract

Introduction

Bacteria present in the apical root canal system are directly involved with the pathogenesis of post-treatment apical periodontitis. This study used a next-generation sequencing approach to identify the bacterial taxa occurring in cryopulverized apical root samples from root canal-treated teeth with post-treatment disease.

Methods

Apical root specimens obtained during periradicular surgery of ten adequately treated teeth with persistent apical periodontitis were cryogenically ground. DNA was extracted from the powder and the microbiome was characterized on the basis of the V4 hypervariable region of the 16S rRNA gene by using paired-end sequencing on Illumina MiSeq device.

Results

All samples were positive for the presence of bacterial DNA. Bacterial taxa were mapped to 11 phyla and 103 genera composed by 538 distinct operational taxonomic units (OTUs) at 3% of dissimilarity. Over 85% of the sequences belonged to 4 phyla: Proteobacteria, Firmicutes, Fusobacteria and Actinobacteria. In general, these 4 phyla accounted for approximately 80% of the distinct OTUs found in the apical root samples. Proteobacteria was the most abundant phylum in 6/10 samples. Fourteen genera had representatives identified in all cases. Overall, the genera *Fusobacterium* and *Pseudomonas* were the most dominant. *Enterococcus* was found in 4 cases, always in relatively low abundance.

Conclusions

This study showed a highly complex bacterial community in the apical root canal system of adequately treated teeth with persistent apical periodontitis. This suggests that this disease

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BASIC RESEARCH – TECHNOLOGY

3-dimensional Ability Assessment in Removing Root Filling Material from Pair-matched Oval-shaped Canals Using Thermal-treated Instruments

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ABSTRACT

Introduction: The purpose of this study was to evaluate the ability of the XP-endo Shaper instrument (FKG Dentaire, La Chaux-de-Fonds, Switzerland) during the removal of root fillings from oval-shaped canals. M-Wire Reciproc and Reciproc Blue systems (VDW, Munich, Germany) were used as reference instruments for comparison, and micro–computed technology was used as an analytical tool. **Methods:** Thirty mandibular incisors with oval-shaped canals were matched based on similar anatomic features of the canal (eg, volume, aspect ratio, and 3-dimensional configuration) after scanning procedures. The canals were prepared with M-Wire Reciproc R25 instruments and filled with gutta-percha and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) using the continuous wave of condensation technique. Then, the sample was allocated into 3 experimental groups ($n = 10$) according to the retreatment protocol used: M-Wire Reciproc, Reciproc Blue, and XP-endo Shaper. M-Wire Reciproc R25, Reciproc Blue R25, and XP-endo Shaper instruments were used to remove the root fillings. Apical enlargement was performed with M-Wire Reciproc R40, Reciproc Blue R40, and BioRace BR5 (FKG Dentaire) instruments. Each sample was scanned after each endodontic procedure. The volume of remaining root filling material was quantified before and after apical enlargement. The percentage volumes of root filling reduction in relation to the instrumented canals at both time points (before and after apical enlargement) were calculated and considered for statistical analysis. Data were analyzed statistically with a significance level of 5%. **Results:** Reciproc Blue presented significantly lower removal of filling material compared with the XP-endo Shaper (Tukey test, $P < .05$). No difference was detected either between M-Wire Reciproc and Reciproc Blue (Tukey test, $P > .05$) or M-Wire Reciproc and XP-endo Shaper (Tukey, $P > .05$). The increase of apical enlargement significantly improved the removal of root fillings from the root canals ($P < .05$); this effect was similar for all systems (time point × file system, $P > .05$). **Conclusions:** The XP-endo Shaper instrument showed a higher percentage of root filling removal, but no differences were observed comparing M-Wire Reciproc with the XP-endo Shaper or Reciproc Blue. The increase of apical enlargement improved the removal of root fillings in all groups. None of them was able to render root canals completely free from root fillings. *(J Endod 2019;45:1135–1141.)*

SIGNIFICANCE

The XP-endo Shaper instrument removed a higher percentage of root fillings. The apical enlargement improved the removal of root fillings in all groups. None of them was able to render root canals completely free from root fillings.

KEY WORDS

Micro–computed tomography; oval-shaped canals; root canal retreatment; root filling material; XP-endo Shaper

The primary goal during root canal retreatment is to remove the previously contaminated filling material, reestablish apical patency, and redo the cleaning and shaping procedures in a proper way[1,2]. Several instruments and techniques were described for the removal of filling materials,

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Evaluation of the Cyclic Fatigue of WaveOne Gold and Reciproc Blue using Different Irrigating Medium

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ABSTRACT

This study aimed to assess the resistance to cyclic fatigue of reciprocating nickel-titanium (NiTi) files (Wave One Gold and Reciproc Blue) and assess the effect of glyde and sodium hypochlorite 5.25% as a gel and liquid on it during testing. A total of 80 new WaveOne Gold primary and Reciproc Blue R25 were tested. The 40 files of the same brand were randomly assigned into four groups (n=8) and submitted to the irrigating protocol as follows: ***Group 1:*** *Testing without irrigating media,* ***Group 2:*** *Testing with glyde,* ***Group 3:*** *Testing with sodium hypochlorite 5.25% gel,* ***Group 4:*** *Testing with sodium hypochlorite 5.25% liquid,* ***Group 5:*** *testing with normal saline (control). The cyclic fatigue test was performed using the appropriate preset reciprocating mode ('RECIPROC ALL' or 'WAVEONE ALL') in a specially designed endodontic motor. Resistance to fracture was determined by recording the time. The instrument tested in stainless artificial canal with 60° angle of curvature and 5 mm radius of curvature. Resistance to cyclic fatigue of the same NiTi was affected by irrigating media. Reciproc Blue R25 was associated with a higher cyclic fatigue resistance in all groups compared to WaveOne Gold Primary. The study concluded that glyde, sodium hypochlorite 5.25% as a gel and as a liquid may reduce the resistance to cyclic fatigue of WaveOne Gold and Reciproc Blue significantly. However, the type of reciprocating instrument influenced cyclic fatigue resistance with Reciproc Blue R25 being more resistant than WaveOne Gold Primary.*

Keywords: Corrosion, Cyclic fatigue, M-wire, Nickel-Titanium, Reciprocating instruments, Sodium hypochlorite 5.25% Gel, Glyde

INTRODUCTION

Two types of fractures occur in the rotating endodontic instrument: fracture caused by flexural fatigue and fracture caused by torsion [1,2].

The cyclic fatigue resistance of NiTi rotary files has been tested by artificial canals with a lot of features, such as the radius and the angle of curvature, the location of the maximum curvature, and the type of artificial canals [3]. When the tip of the instrument or any other part of the instrument become blocked in the canal while the shank still rotates this is called torsional. Torsional fracture occurs when the torque of the hand piece exceeds the elastic limit of the metal [4].

Cyclic fatigue failure may occur without any previous singe of permanent deformation [5,6]. A lot of variable such as: metallurgic characterization of the NiTi alloy, surface treatment of the metal and operational speed may affect the fatigue resistance to fracture [7].

Corrosion that may occur in the NiTi files in the presence of sodium hypochlorite (NaOCl) solution may limit the