ORIGINAL RESEARCH PAPER

Dental Science

FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH WITH CLARK-KHADEMI STYLE ACCESS PREPARATION - AN IN-VITRO STUDY

KEY WORDS: Clark- Khademi access, Soffit, Pericervical dentin.

Piran Mirza Post Graduate Student, Dept. of Conservative Dentistry & Endodontics, Bharati Vidyapeeth Deemed University Dental College & Hospital, Pune.

Ashwini Gaikwad Professor, Dept. of Conservative Dentistry and Endodontics, Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune.

ABSTRACT

Aim: To evaluate the strength of an endodontically treated tooth after preservation of peri-cervical dentin and soffit with Clark - Khademi Style access preparation.

Methodology: 45 human molars having well developed cusps and morphology were extracted for periodontal reasons were included in this study. They were divided in three groups. In gp. A, Clark- Khademi access was made and endodontic treatment was carried out with 2% NiTi K-files, in gp. B, Straight line access was made and endodontic treatment was carried out with 2% NiTi K-files and in gp. C, Straight line aceess was made and endodontic treatment was carried out with 6% Protaper Universal files. Normal endodontic treatment was carried out with the respective files with 17% EDTA as chelating agent and 5.25% Sodium Hypochlorite solution for irrigation. Obturation was carried out using the lateral condensation technique with gutta-percha coated with sealer. After this, the pulp chamber was cleaned thoroughly with cotton and all-in-one bonding agent was applied and scrubbed with an applicator tip for 30 seconds. Next, Composite restoration was done as post-obturation restoration. Specimens were then tested with a universal testing machine, set to deliver an increasing load until failure. Failure was defined as a 25% drop in the applied load. The load was applied parallel to the long axis of the tooth. The variable of interest was the load at failure measured in Newtons.

The data thus obtained was subjected to statistical analysis and was analysed using one way ANOVA test for significance with Bonferroni corrections.

Result: The teeth with Clark-Khademi access preparation with 2% taper of the endodontic files were more efficient at resisting the fracture than the teeth with straight line access preparation with 2% taper & 6% taper of the endodontic files.

Conclusion: The teeth after preservation of pericervical dentin and soffit were found to be structurally reinforced as compared to the teeth with straight line access. Clark-Khademi access preparation was found to be more effective at dentin preservation and strengthening the tooth when compared to straight line access.

Introduction

Access cavity preparation is the first and arguably the most important phase of root canal treatment. A well-designed access preparation is essential for a good endodontic result. Without adequate access, instruments and materials become difficult to handle properly in the highly complex and variable root canal system.[1]

A properly prepared access cavity creates a smooth, straight- line path to the canal system and ultimately to the apex. Ideal access results in straight entry into the canal orifice, with the line angles forming a funnel that drops smoothly into the canal(s). [2]

A Traditional access cavity generally has tapering walls with its widest dimension at the occlusal surface. Stainless steel files were used which were stiffer and were not so efficient in negotiating the curvatures of the root canal. To counter this, a large wider access preparation was advised. [3,4,5] But, wider access preparation done traditionally, resulted in unnecessary dentin removal and hence weakening of the tooth structure. The advent of Nickel-titanium instruments paved way for more conservative access preparations, as these files are super elastic and flexible which can negotiate the canal curvatures easily. Drs. Clark and Khademi have described a concept of conservative endodontic access cavity preparation. This concept negates the traditionalist straight-line access protocol and the total deroofing of the pulp chamber. [6]

Drs. Clark and Khademi have coined the term "soffit", which is a small piece of dentin roof around the entire pulp chamber, to preserve the critical region of peri-cervical dentin (PCD) that is 4mm above and below the crestal bone, without compromising debridement and without inducing iatrogenic misadventure. This type of more constrained, constricted and conservative access cavity encourages the preservation of dentin, thus increasing the strength of the remaining tooth structure and thus prevents the chances of fracture of the tooth.[3,6] The prognosis of endodontically treated teeth depends not only on the success of the treatment but also on the amount of remaining dentin. Fractures of restored endodontically treated teeth are a common occurrence in clinical practice, due to excessive removal of dentin.[7] So improvement in the access cavity preparation to save the unnecessary removal of dentin is required.[6]

In light of these observations, we had planned to evaluate the strength of an endodontically treated tooth after preservation of dentin at the soffit region and at the pericervical area.

Methodology

Forty-five human molars having well developed cusps and morphology were extracted for periodontal reasons were included in this study. The teeth were without caries, anomalies and fractures. This study was conducted in the Department of Conservative Dentistry and Endodontics, Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune.

The teeth were randomly divided into two groups as follows:

GROUPS	SAMPLE SIZE	PROCEDURE
Group A	15	Clark- Khademi style access was made and endodontic treatment was carried out with 2% NiTi K-files.
Group B	15	Straight line access was made and endodontic treatment was carried out with 2% NiTi K-files.
Group C	15	Straight line access was made and endodontic treatment was carried out with 6% Protaper Universal files.

● **Group A** (n=15) – A Large Round bur was used to create the initial access. The central pit of the teeth was selected as the reference point for guiding the bur into the pulp chamber. The position of the bur is held parallel to the long axis of the tooth as all times. After the initial drop into the pulp chamber, a DG-16 probe is used to locate the canals by tactile sensation.

The back end of the explorer or probe is used to check for "soffit," which is the dentin roof around the entire coronal portion of the pulp chamber. A X-ray is made at this stage of the access preparation to check for the soffit radiographically.

● **Group B** (n=15)&**Group C**(n=15) – A Large round bur was used to create the initial access. After the initial drop into the pulp chamber, endo-access preparation bur is used to widen the access preparation till the bur reaches the walls of the pulp chamber, so that a straight-line access is made. A X-ray is made at this stage to check for the straight line access radiographically.

- For Groups A & B - After confirming the X-ray's respectively, normal endodontic treatment is carried out with 2% flexible NiTi K-files with 17% EDTA as chelating agent and 5.25% Sodium Hypochlorite solution for irrigation. Obturation is carried out with the help of spreaders using the lateral condensation technique with gutta-percha coated with sealer.

- For Group C - After confirming the straight line access with the X-ray, endodontic treatment is carried out with 6% Protaper Universal files with 17% EDTA as chelating agent and 5.25% Sodium Hypochlorite solution for irrigation. Obturation is carried out using the single cone obturation technique with gutta-percha cones coated with sealer.

After Obturation is carried out for all the groups, the pulp chamber is cleaned thoroughly with cotton and all-in-one bonding agent is applied and scrubbed with an applicator tip for 30 seconds. After this, another drop of bonding agent is applied and scrubbed again for 30 seconds and then light cured.

Next, Composite is added in small increments (gently tapped with the applicator tip) to adapt properly in the pulp chamber and light cured after every increment. Composite instruments are used to gently carve the occlusal anatomy of the tooth.

Specimens were then tested with a universal testing machine, set to deliver an increasing load until failure. Failure was defined as a 25% drop in the applied load. The crosshead speed was 1 mm per minute, and the load was appliedparallel to the long axis of the tooth.The variable of interest was the load at failure measured in newtons.

The data thus obtained was subjected to statistical analysis and was analysed using one way ANOVA test for significance with Bonferroni corrections.

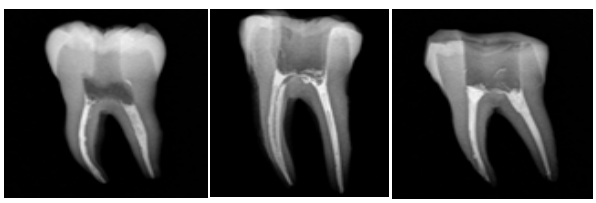
PRE OPERATIVE X-RAY

GROUP A **GROUP B** **GROUP C**

ACCESS CAVITY PREPARATION X-RAY

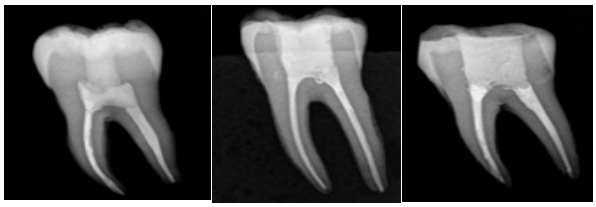
GROUP A **GROUP B** **GROUP C**

OBTURATION X-RAY



GROUP A **GROUP B** **GROUP C**

POST-OBTURATION RESTORATION X-RAY



GROUP A **GROUP B** **GROUP C**

Statistical analysis:

The compressive strength of the samples prepared in each group was expressed as means and standard deviations (mean ± SD). The between group comparison of compressive strength of samples in Group A, B and C was done using One- way ANOVA test. Within group comparison was done using Bonferroni correction test. In the above tests, p value of 0.05 was considered as statistically significant.

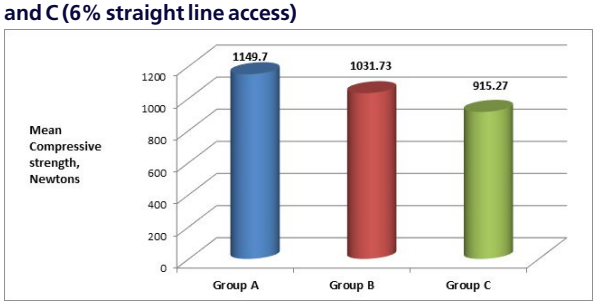
Results:

Table no.1: Comparison of compressive strengths of the samples in Groups A (soffit 2%), B (2% straight line access) and C (6% straight line access)

Compressive strength, Newton	Group A	Group B	Group C	P value (One way ANOVA)
Mean	1149.70	1031.73	915.27	<0.001*
Standard deviation	111.35	71.36	42.69	

*p<0.05 is statistically significant

Figure no.1: Comparison of compressive strengths of the samples in Groups A (soffit 2%), B (2% straight line access) and C (6% straight line access)



Discussion

Endodontically treated teeth are proved to be weaker than vital teeth and are known to present a higher risk of fracture failure when compared to the vital teeth. Hence attention should be paid to unnecessary dentin removal during endodontic treatment, in order to maintain the strength of the teeth[18] Access cavity preparation is the first and arguably most important phase of root canal treatment. A well-designed access preparation is essential for a good endodontic result. Without adequate access, instruments and materials become difficult to handle properly in the highly complex and variable root canal system.[1] The objectives of access cavity preparation is not only to create a smooth, straight-line path, debridement of the entire canal system, reduce the risk of file breakage but also to conserve the sound tooth structure, especially at the pericervical area of the tooth.[2] Traditional endodontic design adheres to straight line access, de-roofing of the pulp chamber and pre-flaring the coronal one-third of the root canal to facilitate the shaping of the entire root canal system in order to negotiate the apical terminus. In order to achieve these objectives, a large amount of tooth structure was compromised.[1]

Gutmann JL et al (1992)noted in his study that there is an excessive removal of radicular dentin during canal cleaning and shaping. The authors also noted that the decrease in the strength of endodontically treated teeth is the result of alteration of coronal tooth structure, which ultimately causes the loss of strength of the tooth.[11]

Henry et al (1977)found that stress transmission to the root became more favourable as coronal dentine was retained and stress concentration at the shoulder reduced.[13]Trabertet al. (1978) emphasized the importance of retaining the maximum amount of sound dentine when restoring root-filled teeth.[13]James W. Robbins (1990)stated in his guidelines for the restoration of endodontically treated teeth that the fracture resistance of a restored endodontically treated tooth decreases as the amount of dentin removed increases.[14]

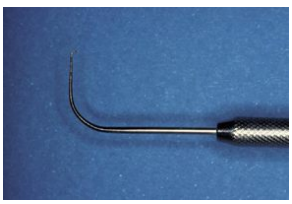
Christine Sedley, Harold Messer (1992)reported that endodontically treated teeth had 35 % lesser stiffness values when compared to the vital teeth.[9]Cecil Williams, Manish Kumar (2014) noted that the most effective conditions for long-term success of the restorative procedure is primarily the preservation of tooth tissue, but without the preservation of dentin, the tooth becomes brittle and susceptible to fracture.[15]

Drs. Clark and Khademi have described the concept of conservative endodontic access preparations by preserving the pericervical dentin and 'soffit', thereby negating the traditional straight line access and the totality of de-roofing the pulp chamber. Soffit is a small piece of roof of the dentin around the entire pulp chamber, and the pericervical dentin, that is 4 mm of dentin above and below the level of crestal bone.[3,4,5]

Papa et al emphasized the importance of conserving the bulk of dentine to maintain the structural integrity of post-endodontically restored teeth.[19]Asudi et al have emphasized that the loss of tooth structure is the key reason for the increase in fracture predilection of endodontictreated teeth.[7]

In light of these observations, the present study was conducted to evaluate and compare the effect of conserving dentin at the region of pericervical dentin and soffit, on the strength of the tooth, with two different types of access preparations. For this study, 45 human molar teeth were collected. As the molars absorbs a more vertical force and, thus the higher net compressive force.[4]

Then the teeth were divided into 3 groups. Group A consisted of Clark- Khademi access preparation and endodontic treatment was carried out with 2% NiTi K-files. As 2% Taper files are less aggressive in dentin rremoval, and thus help in preservation of soffit and pericervical dentin. Lasfargues et al suggested the use of a no.17 small curved probe to check the walls of the access cavity for the presence of soffit. Ardines' probes are also useful for this purpose.[21]



No. 17 Probe Ardine's Probe

Group B consisted of Straight-line access preparation and endodontic treatment was carried out with 2% NiTi K-files. Group B also uses 2% taper files but with straight line access. This group represents the conventional endodontic technique, which is still in use by majority of the clinicians.[6]

Group C also consisted of Straight-line access preparation but endodontic treatment was carried out with 6 % Protaper Universal files. This group represents the gold standard of endodontics since the introduction of Niti instruments a decade ago.[1]

During the complete bio-mechanical preparation, 5.25% Sodium Hypochlorite solution was used as an irrigating solution along with 17% EDTA as a chelator. NaOCl possesses a broad spectrum antimicrobial property, dissolvent of organic tissue and also lubricates the canal for efficient instrumentation. EDTA chelates a stable calcium complexwith dentin mud which helps in removing of canal obstructions and thus further aids in instrumentation. Goldman et al found in his studies that EDTA alone normally cannot remove the smear layer effectively; a proteolytic component (e.g., NaOCl) must be added to remove the organic components of the smear layer.[20]

Gutta-percha was used as an obturating material in all the three groups as it is the universally accepted core material used for obturation. Sealapex (SybronEndo) was used as the sealer in all the three groups. Sealapex is a Calcium hydroxide based sealer which exhibits antimicrobial activity and haveosteogenic–cementogenic potential.[1]

For the post obturation restoration, Composite material, with all-in-one bonding system was chosen for all the 3 groups. In a study by Trope et al, he concluded that acid etching and restoration with a composite resin strengthened the endodontically treated teeth.[17]

The teeth were embedded in autopolymerising acrylic resin blocks upto the cemento-enamel junction. The dimensions of the acrylic block were 15mm X 15mm X 20 mm. This dimension was chosen so that all of the root surface area was adequately covered by the resin and also a sufficient margin of resin was left from the tooth surface, so that the sample doesnot undergo pre-cracking while testing under load.

Universal Testing Machine was used to evaluate the fracture strength of the specimens which was set to deliver an increasing load until failure. Failure was defined as a 25% drop in the applied load. The crosshead speed was 1 mm per minute, and the load was applied to the central pit of the tooth, parallel to the long axis of the tooth. The method of testing was fatigue loading so as to simulate the dynamic forces that act onto the tooth during mastication and swallowing.[4,5] The results were obtained and statistically analyzed.

Table No.1 showed that all the 3 groups could more or less resist the compressive loads; with Group A showing the most statistically significant difference when compared to Group B and Group C, that is the Clark-Khademi access preparation with 2% taper of the endodontic files was the most efficient at resisting the fracture.The reason for this would be the banking of tooth structure; that is dentin preserved at both pericervical region and the soffit.Gutmann JL et al also showed that the mechanical integrity provided by even a small part of the roof of the pulp chamber allows for greater flexure of the tooth during function.[11]

Dentin is primarily a collagen-rich organic matrix reinforced by calcium phosphate mineral particles. The constituents of dentin material are efficiently optimized to different mechanical demands in the mouth.Often, endodontictreated teeth experience tissue loss due to prior pathology or treatment procedures. The loss of dentine tissue will compromise the mechanical integrity of the remaining tooth structure.[7]

The approach of banking of tooth structure in restorative dentistry dictates that whenever possible, more tooth structure should be preserved. It may involve a less expedient, but more conservative, approach. This banked tooth structure may serve as a valuable future asset in the advent of unforeseen future trauma or disease, coupled with the reality that a tooth will need to last for decades and potentially be restored and then rerestored in the patient's lifetime. The primary reason to maintain the soffit is to avoid the collateral damage that usually occurs, by the gouging of the lateral walls.[4,5]

'Soffit' is totally a new concept in access cavity preparation and further research is required to be done on more number of samples to check the strength of the tooth. Research will certainly need to be done to validate other parameters like complete debridement, cleanliness, disinfection etc. with soffit preparation.[4,5,6]

Conclusion

Within the limitations of this in vitro study following conclusions were made:

1. The teeth after preservation of pericervical dentin and soffit were found to be structurally reinforced as compared to the teeth with straight line access.
2. Clark-Khademi access preparation was found to be more effective at dentin preservation and strengthening the tooth when compared to straight line access.
3. An increase in the taper of the files causes more dentin removal in the coronal part of the root canal at the level of the alveolar crest, which in turn depletes the peri-cervical dentin of its thickness and in turn weakens the tooth.

References

1. Frank Vertucci, James Haddix, Chap 7, Tooth Morphology and Access preparation, Pathways of the pulp Cohen 10th Edition.
2. Monnan G, Smallwood ER, Gulabivala K: Effects of accesscavity location and design on degree and distribution ofinstrumented root canal surface in maxillary anterior teeth.IntEndod J 34:176, 2001.
3. Clark D,Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am 2010;54:249-73.
4. Clark D,Khademi J, Herbranson E. Fracture resistant endodontic and restorative preparations. Dent Today 2013;32:118, 120-3.
5. Clark D,Khademi J, Herbranson E. The new science of strong endo teeth. Dent Today 2013;32:112, 114, 116-7.
6. Martin Trope. Bio-minimalism: Trends and transitions in endodontics. Dental Town, April 2016.
7. Anil Kishen. Mechanisms and risk factors for fracture predilection in endodontically treated teeth. Endodontic topics 2006, 13,57-83
8. Carter JM, Sorensen SE, Johnson RR. Punch shear testing of extractedvital and endodontically treated teeth. J Biomech 1983;16:841– 8.
9. Sedgley CM, Messer HH. Are endodontically treated teeth more brittle?J Endodon 1992;18:332–5.
10. Reeh ES. Reduction in tooth stiffness as a result of endodontic restorative procedures. J Endodon 1989;15:512– 6.
11. Gutmann JL. The dentin–root complex: anatomic andbiologic considerations in restoring endodontictreated teeth. J Prosthet Dent 1992: 67: 458–467.
12. Aquilino SA, Caplan DJ. Relationship between crown placement andthe survival of endodontically treated teeth. J Prosthet Dent 2002;87:256 – 63.
13. A.Al-Wahadni&D.L.Gutteridge. Anin vitroinvestigation into the effects of retainedcoronal dentine on the strength of a tooth restoredwith a cemented post and partial core restorationIntEndod J 2002;35:913– 8.
14. Robbins JW. Guidelines for the restoration of endodontically treatedteeth. J Am Dent Assoc 1990;120:558 – 66.
15. Goodacre CJ, Spolnik KJ. The prosthodontic management of endodontically treated teeth: a literature review. Part I. Success and failure data,treatment concepts. J Prosthodont 1994;3:243–50.
16. Dietschi D, Duc O, Krejci I,Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, part II (evaluation of fatigue behavior, interfaces, and in vivo studies). Quintessence Int 2008; 39:117-29.
17. Trope M, Maltz DO, Tronstad L. Resistance to fracture of restoredendodontically treated teeth. Endod Dent Traumatol 1985;1:108 –11.
18. Akkayan B, Gulmez T. Resistance to fracture of endodontically treatedteeth restored with different post systems. J Prosthet Dent 2002;87:431.
19. Papa J, Cain C, Messer HH. Moisture content of vital vsendodontically treated teeth. Endod Dent Traumatol1994: 10: 91–93.
20. Goldman M, Kronman JH, Goldman LB, Clausen H, GradyJ: New method of irrigation during endodontic treatment.J Endod 2:257, 1976.
21. Lasfargues, j.j., laison, f., levy, g.: Le vie d'accesso inendodonzia. Dental Cadmos 4:85, 1984.
22. Ioanna S. Arvaniti, Marouan G. Khabbaz, Influence of Root Canal Taper on Its Cleanliness: A ScanningElectron Microscopic Study. JOE — Volume 37, Number 6, June 2011
23. Lee HL, Orlowski JA, Schedit GC, Lee JR. Effects of acid etchants on dentin. J dent res 1973 52:1228
24. Tan PL, Aquilino SA, Gratton DG, et al. In vitro fracture resistance of endodontically treated central incisors with varying ferrule heights and configurations. J Prosthet Dent 2005;93(4):331–6.
25. Al-Hazaimeh N, Gutteridge DL. An in vitro study into the effect of the ferrule preparation on the fracture resistance of crowned teeth incorporating prefabricated post and composite core restorations. IntEndod J 2001;34(1):40–6.
26. Ericson D, Kidd E, McComb D, Mjör I, Noack MJ. Minimally invasive dentistry – Concepts and techniques in cariology. Oral Health Prev Dent 2003;1:59-72.