Original Article

Influence of access cavity design on root canal instrumentation efficacy in molars – An *in vitro* study

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Abstract

Background: Several designs of access cavity have been evolved in the recent past with the concept of minimal tooth tissue removal which would improve the root canal treated teeth fracture resistance.

Aim: To investigate the effect of conservative design access cavity during the instrumentation of maxillary molar root canals.

Materials and Methods: Eighty noncarious maxillary molars were assigned to the traditional and conservative access groups (n = 40 each). After designated access preparations, the teeth were immersed in Lugols's solution for staining the pulp tissue. Root canal instrumentation was performed with TruNatomy file system. Pre- and postinstrumentation nano-computed tomography (CT) images were taken and reconstructed using CT-An software. Root canals volumetric analysis was done with CT-Vol software. The analysis of the data was dealt with Shapiro–Wilk test and independent t-test.

Results: The volume of pulp canal space before and after instrumentation changed significantly between the traditional and conservative access design groups, according to an independent t-test. In comparison, the mean volume of dentin removed was much larger in the TAC group (P = 0.0016). The independent t-test manifests difference significantly between traditional endodontic access cavity (TAC) and conservative access cavity (CAC) with percentage of unprepared canal walls. The mean percentage of unprepared area was significantly lesser in TAC group as compared to CAC group (P = 0.0022).

Conclusion: The volume of dentin removed was greater in TAC than with the CAC design. The amount of untouched canal wall area was significantly higher in conservative access design than with the traditional access design group.

Keywords: Conservative access cavity; instrumentation efficacy; nano-computed tomography; traditional access cavity; TruNatomy NiTi files

INTRODUCTION

The first and the critical step in endodontic treatment is coronal access preparation that allows straight line access from the canal orifices to apical foramen, which enables controlled instrumentation and obturation of the root canal system. Traditional endodontic access cavity (TAC) preparation causes destruction of peri-cervical dentin (PCD) that increases the cuspal flexure and reduces the rigidity and stiffness eventually leading to the fracture of endodontically treated teeth (ETT).[1,2] Currently, with the innovations in therapeutic irrigation devices and flexible rotary instruments, the conservative access cavity (CAC) preparation is an alternative feasible clinical procedure. As CAC preparation does not require complete de-roofing of pulp chamber and allows undermined dentin preservation, facilitating improved fracture resistance of treated tooth.[3] However, several recent studies have shown no apparent difference TAC and CAC designs, with regard to fracture strength of ETT.[4-6]

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The minimally invasive access cavity designs can compromise the root canal disinfection efficacy through missed canals, canal deviations, and file separation.[7] The residual microbial content was also significantly high with CAC (86%) compared to TAC (50%) after root canal instrumentation.[8,9] Hence, the motive of present investigation was to evaluate the proportion of removed dentin from the canal walls and the probability of unprepared canal space, in maxillary molars with TAC and CAC preparations that were instrumented with TruNatomy files.

MATERIALS AND METHODS

This *ex vivo* study was conducted following the PRILE 2021 guidelines in endodontology. Periodontally compromised, recently extracted anatomically matched 80 maxillary molars were used in the study. Radiographs were taken both in mesio-distal and vestibulo-lingual directions to exclude teeth with internal resorptions and partial or total pulp canal obliterations. Molar teeth having moderate canal curvature of 5°–20°, according to Schilder method and with similar root length were recruited for the study. For accomplishing analysis with 95% power and type I error of 5%, a total of 80 sample size was established to identify the compelling differences between TAC (n = 40) and CAC (n = 40) groups.

Access cavity preparation

Based on the external morphology of maxillary molar tooth, the access cavity size and shape have been assessed. The perimeter of the traditional access design was guided by the internal anatomy of the pulp chamber and was prepared using BR-45 round bur (Mani Inc, Tochigi, Japan) and endo access bar (Dentsply Maillefer, Switzerland). Occlusally divergent access cavity walls with the elimination of pulp chamber roof were accomplished by EX-24 diamond bur (Mani Inc, Tochigi, Japan) [Figure 1]. The CAC was prepared by marking the landmarks on the occlusal surface, suggested by Balagopal *et al.* [Figure 1].[10] The canal orifices and their patency was verified with DG-16 endodontic explorer. Both the traditional and the conservative access design were done under ×3.5 magnification.

Staining the pulp tissue

The staining Lugol solution that constitutes 5% iodine and 10% potassium iodide was prepared by dissolving 2.5 g of iodine and 5 g of potassium iodide in 250 ml distilled water. Access prepared molar teeth were covered with modeling wax, excluding the access opening and were immersed in Lugol's solution for 7 days to permit pulpal tissue staining.[11] All the 80 molars were scanned and reconstructed to assess pulp canal space volume that was impregnated with Lugol's contrast media.

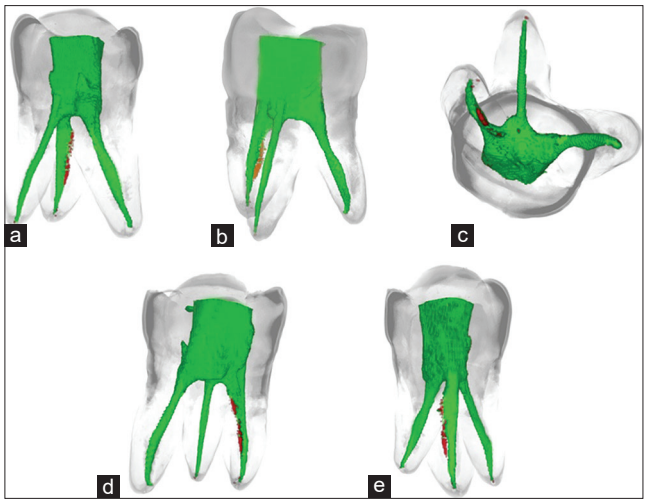

Figure 1: Superimposed 3D models of mesial (a), distal (b), apical(c), buccal (d) and palatal (e) regions of root canals with Traditional access cavity design

Root canal shaping

All the molar root canals were instrumented in a crown-down manner with TruNatomy rotary system (Dentsply Sirona, Switzerland). After the initial instrumentation with hand files, rotary instruments were used in a sequential order of 17/0.02, 20/0.04, 26/0.04, and 36/0.08, respectively, using E-connect S endomotor (Orikam, China) at 500 rpm speed with 1.5 NCm torque under 3.5× magnification. During instrumentation, the root canals were debrided using 3% NaOCl and then 17% (Ethylenediaminetetraacetic acid) EDTA irrigation with Rc Twent side vent (Prime Dental, India) needles. Final irrigation was completed by agitating 3% NaOCl irrigant for 1 min in each canal using IRRI 20 ultrasonic activation (Satelec/Aceteon, France).

Obtaining nanocomputed tomography images

Nano-CT scanning was performed at two time periods (i) immediately after conservative and traditional access preparations and (ii) after cleaning and shaping the root canals. The teeth were scanned with 80 KVp and field of view was 4 cm × 5 cm with 75 voxel size and 65 nm pixel resolution. The volume of root canals was calculated in cubic millimeters and computed tomography (CT)-Vol software was used to superimpose the scanner images. The dentin volume removed in each tooth after instrumentation was measured by subtracting postpreparation volume from the initial pulp canal volume. Static voxels or the number of voxels present in the same position in the root canal surface before and after instrumentation are used to calculate the precise proportion of prepared and unprepared canal dimensions.[11]

Statistical analysis

Statistical analysis was applied to the obtained data deploying the SPSS statistics, version 22.0 (IBM, Armonk, NY, USA) software. According to Shapiro–Wilk test, the

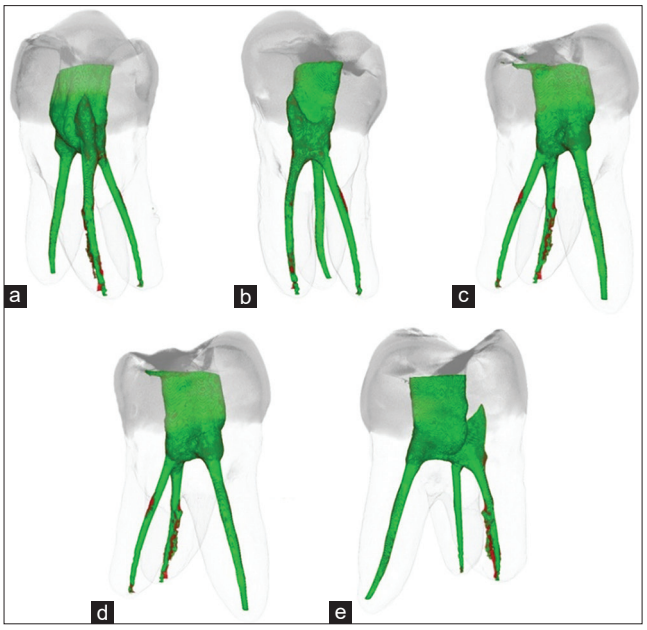

Figure 2: Superimposed 3D models of buccal (a), palatal (b and c), mesial (d) and distal (e) regions of root canals with Conservative access cavity design. Areas in green corresponds to instrumented region and red corresponds to non-instrumented region

initial pulp canal volume presented normal distribution in both test group samples. Inter-groups and intra-group comparison was done using the independent *t*-test. The data were analyzed with 95% confidence interval where $P < 0.05$ was contemplated significant.

RESULTS

Significant difference for pulp canal space volume was noticed before and after instrumentation ($P = 0.0001$) in both access design groups. The mean dentin volume removed in TAC group was significantly more (1.83 mm^3) compared to CAC group (1.39 mm^3) with $P = 0.0016$, as shown in Table 1. The nano-CT superimposed images of traditional and conservative access designs are presented in Figures 2 and 3. The independent *t*-test showed a significantly higher mean percentage of prepared pulp canal space in TAC group compared to CAC group [Table 2]. The untouched pulp canal space was significantly less for TAC group ($P = 0.0022$).

DISCUSSION

The published research established that, the survival and durable prediction of ETT is strongly associated with the residual tooth structure.[1,2] Preservation of 8 mm critical zone of PCD is crucial for maintaining the biological periodontal health and to transfer the masticatory occlusal load evenly to the root.[12] Excessive tooth reduction axially for placing extracoronal restoration and extended

Table 1: Comparision of mean volume of pulp canal space before and after instrumentation by independent *t*-test in traditional and conservative access cavity groups

Groups	Mean	SD	SE	*t*	*P*
TAC	1.83	0.66	0.10	3.2651	0.0016*
CAC	1.39	0.54	0.09		

*$P<0.05$ indicate significant difference. SD: Standard deviation, SE: Standard error, CAC: Conservative access cavity, TAC: Traditional access cavity

Table 2: Comparision of mean percentage of prepared pulp canal area after instrumentation by independent *t*-test in traditional and conservative access cavity groups

Groups	Mean	SD	SE	*t*	*P*
TAC	78.87	6.80	1.08	3.1689	0.0022*
CAC	74.24	6.27	0.99		

*$P<0.05$ indicate significant difference. SD: Standard deviation, SE: Standard error, CAC: Conservative access cavity, TAC: Traditional access cavity

endodontic access are the major insults to the PCD. The minimally invasive endodontic concept advocates the maximum amount of tooth structure preservation. That includes PCD, roof of pulp chamber, oblique, and marginal ridges of a involved tooth. This is in accordance with the study conducted by Varghese *et al*. that showed significant preservation of PCD when conservative access preparation was done.[23]

Different researchers have related the coronal access cavity preparation designs influence the root canal treated tooth fracture causing treatment failure.[12,13,24] Hence, it is necessary to quantify the loss of root dentin structure during cleaning and shaping procedures with different operative approaches. Even though CAC design conserves PCD, a recent laboratory studies related systematic review stated that CAC preparation may not increase the ETT resistance to fracture.[4]

The TruNatomy rotary system was developed basically for minimal endodontic invasive procedures. These regressive tapered, heat treated instruments are having minimal flute diameter and highest degree of flexibility.[14,15] With regard to dentin preservation along with effective and faster canal preparation, TruNatomy files offer superior canal debridement, adhering to the original canal anatomy.[9] According to the study results, TAC preparation lead to more amount of dentin removal (1.83 mm^3) in maxillary molars compared to CAC (1.39 mm^3) design, correlating with several published results.[1,14] However, the reduction in the apical part of PCD was not significantly different between TAC and CAC in a recent study by Peng *et al*.[16] They attributed this coronal dentin preservation to the use of regressive tapered instruments compared to preparation with progressive or greater taper instruments.

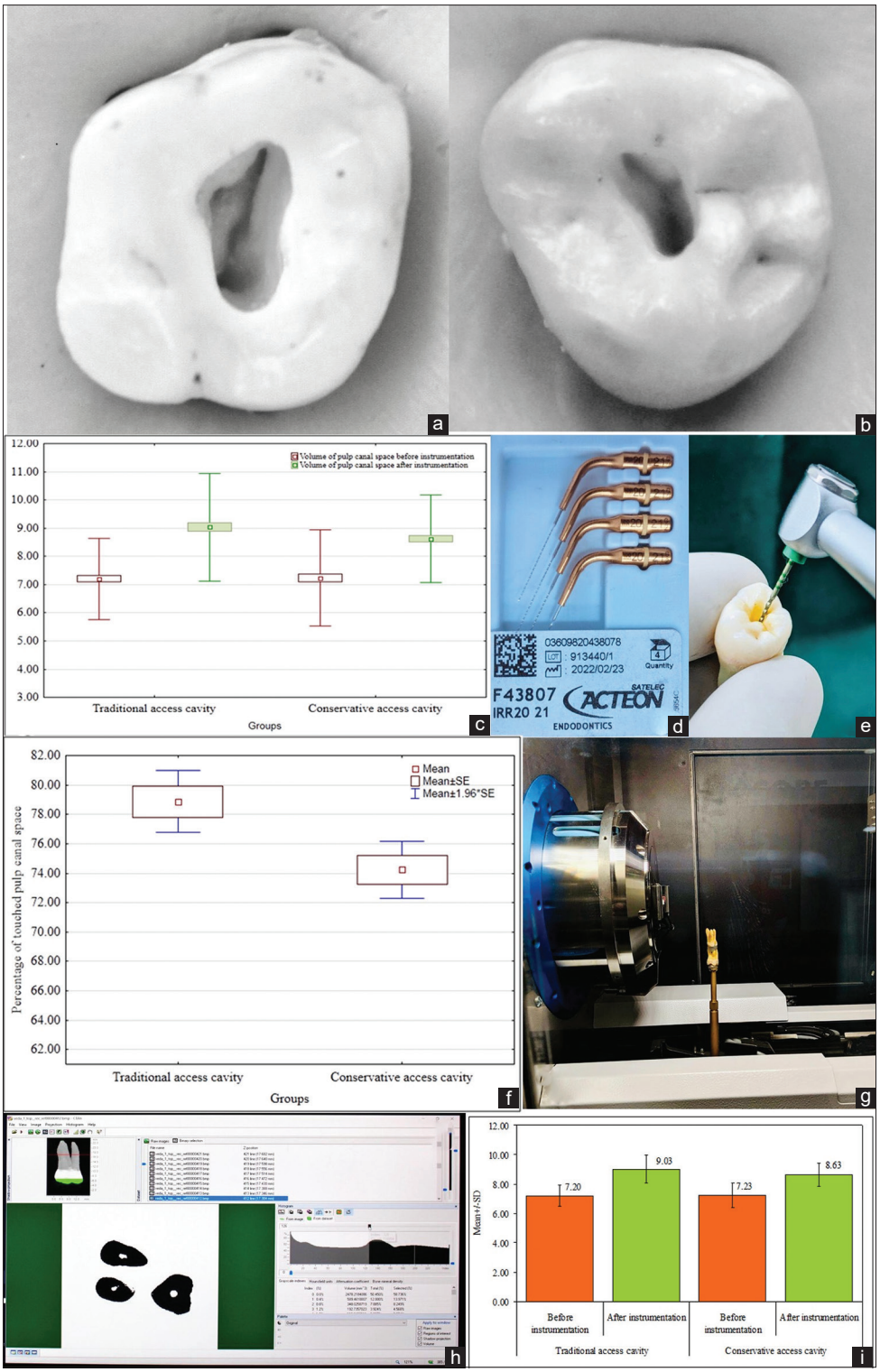

Figure 3: (a) Traditional Access Cavity (TAC), (b) Conservative Access Cavity (CAC), (c) Box plot: volume of pulp canal space multiple variables aggregated by group means, (d) Ultrasonic tips (IRRI20; Satelec/Acteon, Merignac, France.), (e) TruNatomy file system, (f) Box plot: percentage of touched pulp canal space, (g) NANO-CT Scanning, (h) CT-Vol software, (i) Whisker plot: mean volume of pulp canal space

Minimal invasive endodontic procedures can compromise the goals of access cavity preparation by negatively influencing the root canal disinfection protocol.[17] The presence of untouched root canal areas during shaping procedures may cause colonization of microbial biofilm, debris accumulation, and apical transportation leading to persistence of infection and failure of endodontic treatment.[8] A greater amount of unprepared root canal

system and increased risk of instrument separation was observed in ultra-conservative and conservative preparations compared to TAC.[1,18]

In order to simultaneously assess the soft and hard tissues of a tooth qualitatively and quantitatively, a nondestructive, reliable method is the utilization of contrast media. Lugol's iodine (I_2KI) is the simple, nontoxic, costeffective contrast media which can rapidly differentiate the soft tissues diversities rapidly.[11] Contrast-enhanced nano-CT enabled us to assess the remnants of pulp tissue quantitatively after the instrumentation of root canals.

The contrast CT results revealed that the mean proportion of untouched canal area after instrumentation was higher for CAC group compared to TAC, which is consistent with the results of earlier investigations.[14,19,20] Contrary to these results, few studies demonstrated adequate root canal instrumentation with CAC, without any significant difference compared to TAC designs.[16,21,22] Since straight-line access is absent in CAC, the instrumentation efficacy reduces, increasing the chance of iatrogenic perforation and transportation.[23] The strip perforations are inevitable, especially on the distal wall of maxillary molar mesiobuccal roots and mandibular molar mesial roots due to the relatively thin dentinal wall under the furcation area.[16]

The present study investigation was performed on intact noncarious molars, but clinically most teeth that require root canal therapy are structurally compromised with caries and thus CAC preparation design may not be practical in most of the cases. However, if prepared properly, whether it is TAC or CAC or ultra CAC, the access designs may not exceed occlusal one fourth surface. Hence, to show the clear benefits of these conservative preparations, clinical trials are mandatory.

CONCLUSION

Within the limitations of this study, the TAC design required the greatest volume of dentin removal followed by the CAC designs. The correlative analytical technique using nano-CT imaging was effective in demonstrating the conditions of the root canal walls that remained unprepared by instruments, with CAC comprising more untouched canal area than TAC. TruNatomy effectively prevented over enlargement of the canals safeguarding the structural dentin in both traditional and conservative access design. Although the CAC design showed areas unaffected by preparation, further antibacterial techniques such as ultrasonic agitation of NaOCl can contribute to improved disinfection.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Krishan R, Paqué F, Ossareh A, Kishen A, Dao T, Friedman S. Impacts of conservative endodontic cavity on root canal instrumentation efficacy and resistance to fracture assessed in incisors, premolars, and molars. J Endod 2014;40:1160-6.
2. Ibrahim AM, Richards LC, Berekally TL. Effect of remaining tooth structure on the fracture resistance of endodontically-treated maxillary premolars: An *in vitro* study. J Prosthet Dent 2016;115:290-5.
3. Plotino G, Grande NM, Isufi A, Ioppolo P, Pedullà E, Bedini R, *et al.* Fracture strength of endodontically treated teeth with different access cavity designs. J Endod 2017;43:995-1000.
4. Silva EJ, Rover G, Belladonna FG, De-Deus G, da Silveira Teixeira C, da Silva Fidalgo TK. Impact of contracted endodontic cavities on fracture resistance of endodontically treated teeth: A systematic review of *in vitro* studies. Clin Oral Investig 2018;22:109-18.
5. Moore B, Verdelis K, Kishen A, Dao T, Friedman S. Impacts of contracted endodontic cavities on instrumentation efficacy and biomechanical responses in maxillary molars. J Endod 2016;42:1779-83.
6. Corsentino G, Pedullà E, Castelli L, Liguori M, Spicciarelli V, Martignoni M, *et al.* Influence of access cavity preparation and remaining tooth substance on fracture strength of endodontically treated teeth. J Endod 2018;44:1416-21.
7. Silva EJ, Pinto KP, Ferreira CM, Belladonna FG, De-Deus G, Dummer PM, *et al.* Current status on minimal access cavity preparations: A critical analysis and a proposal for a universal nomenclature. Int Endod J 2020;53:1618-35.
8. Vieira GC, Pérez AR, Alves FR, Provenzano JC, Mdala I, Siqueira JF Jr., *et al.* Impact of contracted endodontic cavities on root canal disinfection and shaping. J Endod 2020;46:655-61.
9. Falakaloglu S, Silva E, Topal B, Iriboz E, Gundogar M. Shaping ability of modern Nickel-Titanium rotary systems on the preparation of printed mandibular molars. J Conserv Dent 2022;25:498-503.
10. Balagopal S, Chandrasekaran C. Structure bound guide to access cavity preparation for molar root canal treatment. Indian J Dent Res 2020;31:621-4.
11. De-Deus G, Belladonna FG, Cavalcante DM, Simões-Carvalho M, Silva EJ, Carvalhal JC, *et al.* Contrast-enhanced micro-CT to assess dental pulp tissue debridement in root canals of extracted teeth: A series of cascading experiments towards method validation. Int Endod J 2021;54:279-93.
12. Clark D, Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am 2010;54:249-73.
13. Kishen A. Biomechanics of fractures in endodontically treated teeth. Endod Topics 2015;33:3-13.
14. Silva EJ, Lima CO, Barbosa AF, Lopes RT, Sassone LM, Versiani MA. The impact of TruNatomy and ProTaper gold instruments on the preservation of the periradicular dentin and on the enlargement of the apical canal of mandibular molars. J Endod 2022;48:650-8.
15. Manocha SK, Saha SG, Agarwal RS, Vijaywargiya N, Saha MK, Surana A. Comparative evaluation of canal transportation and canal centering ability in oval canals with newer nickel-titanium rotary single file systems – A cone-beam computed tomography study. J Conserv Dent 2023;26:326-33.
16. Peng W, Zhou X, Gao Y, Xu X. Effect of access cavity preparation on dentin preservation, biomechanical property, and instrumentation efficacy: A micro-computed tomographic study. J Endod 2022;48:659-68.
17. Shabbir J, Zehra T, Najmi N, Hasan A, Naz M, Piasecki L, *et al.* Access cavity preparations: Classification and literature review of traditional and minimally invasive endodontic access cavity designs. J Endod 2021;47:1229-44.
18. Zhang Y, Liu Y, She Y, Liang Y, Xu F, Fang C. The effect of endodontic access cavities on fracture resistance of first maxillary molar using the extended finite element method. J Endod 2019;45:316-21.
19. Barbosa AF, Silva EJ, Coelho BP, Ferreira CM, 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. Int Endod J 2020;53:1666-79.
20. Perez Morales ML, González Sánchez JA, Olivieri Fernández JG, Laperre K, Abella Sans F, Jaramillo DE, *et al.* TRUShape versus XP-endo shaper: A micro-computed tomographic assessment and comparative study of the shaping ability-An *in vitro* Study. J Endod 2020;46:271-6.
21. Rover G, de Lima CO, Belladonna FG, Garcia LF, Bortoluzzi EA, Silva EJ, *et al.* Influence of minimally invasive endodontic access cavities on

root canal shaping and filling ability, pulp chamber cleaning and fracture resistance of extracted human mandibular incisors. Int Endod J 2020;53:1530-9.
22. Sabeti M, Kazem M, Dianat O, Bahrololumi N, Beglou A, Rahimipour K, *et al.* Impact of access cavity design and root canal taper on fracture resistance of endodontically treated teeth: An *ex vivo* investigation. J Endod 2018;44:1402-6.
23. Varghese VS, George JV, Mathew S, Nagaraja S, Indiresha HN, Madhu KS. Cone beam computed tomographic evaluation of two access cavity designs and instrumentation on the thickness of peri-cervical dentin in mandibular anterior teeth. J Conserv Dent 2016;19:450-4.
24. Sundar S, Varghese A, Datta KJ, Natanasabapathy V. Effect of guided conservative endodontic access and different file kinematics on debris extrusion in mesial root of the mandibular molars: An *in vitro* study. J Conserv Dent 2022;25:547-54.