**Impact of Contracted Endodontic Cavities on Occurrence of Endodontic Mishaps- A Systematic Review.**

**Background**- Conservative endodontic cavities have gained popularity because it preserves sound dentin, most importantly the peri-cervical dentin. It is said that the preservation of peri-cervical dentin increases the fracture resistance of the tooth. But, due to restricted path of insertion of endodontic instruments conservative endodontic cavities may lead to mishaps like; missed canals, canal transportation, ledge formation and separation of instrument.

**Objectives-** To evaluate by the means of a systematic review that whether contracted endodontic cavities increased the incidence of endodontic mishaps.

**Methods**- An electronic data search was performed on PubMed, Cochrane, google scholar and EBSCO host from 1/01/2012 to 30/09/2022. Literature available in English language were only researched. In-vitro and ex-vivo studies performed on extracted human teeth which answered the research question were included. Review articles and case reports were excluded. The quality assessment of the studies was done by using the Joanna Briggs Appraisal checklist for cohort studies.

**Results-** Out of 652 searched articles 13 articles were found relevant for the systematic review, out of which 3 authors discussed impact of contracted endodontic cavities on missed canals, 4 authors discussed impact of contracted endodontic cavities on instrument separation and 6 authors discussed the impact of contracted endodontic cavities on canal transportation.

**Conclusions**- Contracted endodontic cavities are proven to reduce the volume of dentin removed, but this may or may not be of advantageous for the biomechanical properties of the endodontically treated tooth. Due to contracted size of the cavity; increased incidences if endodontic mishaps are seen in CEC’s.

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**Conflicts of interest- NIL**

**Registration- PROSPERO-** CRD42022340647

**Introduction-**

Diseases of pulp and periodontal tissues causes pain and periapical pathology, which can be effectively treated by endodontic therapy. The goals of endodontic therapy are to increase the longevity of the tooth by removing all the infected pulp, disinfecting the root canals, and filling the canals with an inert material and rehabilitating the tooth with a suitable restoration. 1–3

The access is gained to the pulp chamber by preparing an access cavity, which involves removal of enamel and dentin. The goals of a good endodontic access cavity are to have visibility, access to all main and accessory canals, provide pathway for irrigating solution and medicaments, obturating material as well as to maintain the integrity and longevity of the tooth. Traditional endodontic cavity (TEC) preparation involved the removal of large amount of tooth structure which is said to impact the strength of the tooth. The interest in minimally invasive access cavity is because preservation of dentin; most importantly the peri-cervical dentin increases the fracture resistance of endodontically treated tooth.4–6The minimally invasive access cavities includes; the conservative endodontic access cavities, contracted endodontic access cavity (CEC), and truss access cavity (TAC) and ninja access cavity (NAC). These access cavity types preserved the dentin but are also known to cause endodontic mishaps majorly due to the size of the access cavity and the restricted path of entry of the endodontic instruments. This may cause missed canals, canal transportation, ledge formation, instrument separation. These mishaps may have a negative impact on the endodontic therapy which may cause treatment failure.

Al Fouzan et al reported that MB2’s have an incidence of 97% in maxillary 1st molars and 93% in maxillary second molars. (Alfouzan et al., 2019) Missed canals contributed to 18 % of all endodontic mishaps(Iqbal, 2016)and are associated with high prevalence of persistent apical periodontitis.(Costa et al., 2019a) Evidence says that only 70% (Maxillary first molar) and 61% (Maxillary second molar) MB2’s were detected immediately after access opening, but in other cases detection of MB2 required troughing and preparation of the pulp chamber floor. (Alfouzan et al., 2019)

Cleaning and disinfecting the root canals thoroughly is one way to a predictable root canal therapy. Biomechanical preparation of the canals is important for enabling the disinfecting solutions and irrigating solutions to enter and reach the canals up to the apical third and disinfect adequately. The instrumentation efficacy may(Shroff et al., 2022) or may not (Wang et al., 2021a)(Moore et al., 2016) be affected by the size of the access cavity. It is reported that contracted endodontic cavities compromises the cleaning and disinfecting of the canals(Vieira et al., 2020a); on the other hand, there is literature which also suggests that cleaning efficacy is not related to the size of the access cavity.

Instrument separation is one of most undesirable mishap which occurs during instrumentation procedure. Instruments fracture in the root canals mainly due to torsional fracture and flexural fatigue.(McGuigan et al., 2013a) The access cavity size may add to the torsional stress and cause fracture also if the operator is trained enough and knows the proper technique the access cavity may not have any influence on the incidence of instrument separation.

Shaping and cleaning of the root canals is the most critical step in the success of a root canal therapy. Mishaps, or errors in the above is not desirable at the cost of preservation of tooth structure.

With advancements in clinical techniques (isolation, ultrasonics, and magnification) these mishaps could be avoided, but the risk persists. Thus, the following systematic review focuses on assessment of whether contracted access cavity designs cause increased incidences of endodontic procedural mishaps.

General objectives are-

* To describe the clinical applications of contracted endodontic access cavities.
* To assess the possible procedural mishaps occurring during endodontic therapy.
* To assess whether the procedural errors have higher incidences in cases of contracted endodontic cavity designs.
* To formulate a risk vs benefit assessment for contracted endodontic access cavities.

**Methods –**

The protocols of the following systematic review were based on the PRISMA checklist(Page et al., n.d.) It is registered with the international prospective register of systematic reviews- PROSPERO Database (CRD42022340647).

A search strategy of literature was performed on PubMed, Cochrane, Google scholar and EBSCO Host from 1/01/2012 to 30/09/2022; with MeSH terms “contracted endodontic cavity” “conservative endodontic access cavity” “ultraconservative endodontic access cavity” “truss access cavity” “ninja access cavity” “endodontic mishaps” “incidence of missed canals” “instrument fracture” “ledge formation” “Canal transportation”.

Electronic search was done by two separate researchers. The following combination of keywords were used in the Boolean criteria for the electronic search "Contracted endodontic cavity" OR "ultraconservative endodontic cavity" AND "incidence of missed canals" OR "Canal transportation" OR "ledge formation" OR "Instrument separation". To ensure, each keyword was searched separately also.

**Eligibility criteria-**

The inclusion criteria of the studies were based on the ‘PICOS’ strategy. The selected studies were which included extracted human teeth which underwent root canal therapy(P) and in which contracted endodontic cavities were to be prepared and biomechanical preparation was done (I), and were compared with traditional endodontic cavities(C). This evaluated the incidence of occurrence of endodontic mishaps(O) in in-vitro conditions(S).

Study selection- Two researchers reviewed independently the complete list of articles and selected the relevant articles by their title and abstract. Later full text screening was performed and according to the inclusion and exclusion criteria of the systematic review. In case of discrepancies, differences were discussed by all the authors until agreement was reached.

**Data extraction-**

Data extraction was carried out by two different authors independently, articles which described access cavity size and endodontic mishaps together were selected and full text articles were retrieved. For articles which were not available as full text, respective authors were contacted via Email to retrieve the full text versions.

**Quality of the evidence assessment-**

Joanna Briggs Appraisal criteria was used to assess the quality of the shortlisted articles, care reports and reviews were eliminated. Experimental in-vitro studies on human extracted teeth were only included and studies performed on 3D printed teeth or artificial teeth were excluded.

Joanna briggs appraisal-

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| Sr.no | Author, year |  |  | | |  |  | |  | | | JBI criteria no. | |  | |  | |  | |  | |  | |
|  |  | 1. Were the two groups similar and recruited from the same population? | | 2. Were the exposures measured similarly to assign people to both exposed and unexposed groups? | 3. Was the exposure measured in a valid and reliable way? | | | 4. Were confounding factors identified? | | 5. Were strategies to deal with confounding factors stated? | 6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)? | | 7. Were the outcomes measured in a valid and reliable way? | | 8. Was the follow up time reported and sufficient to be long enough for outcomes to occur? | | 9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored? | | 10. Were strategies to address incomplete follow up utilized? | | 11. Was appropriate statistical analysis used? | |
| 1. | Giacomo Corsentino ,2021(Corsentino, 2021a) | Y | | Y | Y | | | Y | | N | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 2. | Mario Alovisi et al;2017(Alovisi et al., 2018a) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 3. | Blauhut et al; 2020(“EBSCOhost | 150785246 | Reliability of root canal orifice assessments using minimally invasive access cavities.,” n.d.) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 4. | [Gokhan Saygili](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Saygili+G&cauthor_id=29980211) et al;2018(Saygili et al., 2018) | Y | | Y | Y | | | N | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 5. | A.F.A Barbosa et al;2020(Barbosa et al., 2020a) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 6. | [C. O. Lima](https://onlinelibrary.wiley.com/action/doSearch?ContribAuthorRaw=Lima%2C+C+O) et al ;2021(Lima et al., 2021a) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 7. | Travis Moore et al;2017(Moore, 2018a) | N | | N | Y | | | N | | N | Y | | N | | N.A | | N.A | | N.A | | N | |
| 8. | [WeiqiPengMD](https://www.sciencedirect.com/science/article/abs/pii/S0099239922001066#!) et al;2021(Peng et al., 2022a) | Y | | N | N | | | N | | N | N | | Y | | NA | | NA | | NA | | Y | |
| 9. | Gabriela Rover et al;2017(Rover et al., 2017) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 10. | Rodrigo Dantas et al; 2021(Pereira et al., 2021) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 11. | Dan Wang et al; 2021(Wang et al., 2021b) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 12. | [Emmanuel João Nogueira Leal Silva](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Silva+EJNL&cauthor_id=33219876) et al; 2021(Emmanuel João Nogueira Leal Silva et al., 2020) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 13. | [Ana Raquel Lopes Dos Santos Miranda](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Dos+Santos+Miranda+ARL&cauthor_id=34561894) et al; 2021(dos Santos Miranda et al., 2022a) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 14. | [C M Augusto](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Augusto+CM&cauthor_id=32683704) et al 2020 | Y | | N | N | | | N | | N | Y | | N | | N.A | | N.A | | N.A | | Y | |
| 15. | [Ana Flávia Almeida Barbosa](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Barbosa+AFA&cauthor_id=35697303) et al 2022. | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 16. | [E J N L Silva](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Silva+EJNL&cauthor_id=32749715)et al 2020. | Y | | Y | N | | | N | | N | N | | N | | N.A | | N.A | | N.A | | Y | |
| 17. | [A A Silva](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Silva+AA&cauthor_id=31519039) et al 2020. | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 18. | |  |  | | --- | --- | | [Ahmed M. Bayoumi](https://journals.ekb.eg/?_action=article&au=478293&_au=Ahmed+M.+Bayoumi)et al 2022(Bayoumi et al., 2022). | | |  |  | | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 19. | [Gaya C.S.Vieira](https://www.sciencedirect.com/science/article/abs/pii/S0099239920300832#!) et al 2020(Vieira et al., 2020b) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 20. | Xia, Juan et al 2020 (Xia et al., 2020) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |
| 21. | Valentina Spicciarelli et al 2020(Spicciarelli et al., 2020) | Y | | Y | Y | | | Y | | Y | Y | | Y | | N.A | | N.A | | N.A | | Y | |

**Results-**

1. **Search results** – A total of 652 articles were searched; 305 from PubMed, 71 from Cochrane, 250 from EBSCO host and 26 from google scholar, and were stored in a reference manager. Duplicate records (n=12) were excluded. Articles which did not meeth the inclusion criteria i.e, case reports and review articles (n=14) were also excluded.

Further, 604 articles were found to be irrelevant by their title and abstracts and were excluded.

Reports sought for retrieval were 22, out of which 1 report was not retrieved, thus 21 reports went through quality assessment and eligibility. Experimental study by Travis Moore et al(Moore, 2018b) was excluded because it was performed on artificial 3-D printed teeth. A comparative experimental study by Barbosa A et al(Barbosa et al., 2022) was excluded, as it assessed dentinal microcracks after instrumentation. Another study by ENJL Silva et al(E. J.N.L. Silva et al., 2020) was eliminated as it evaluated gaps and voids in restoration with contracted endodontic access cavity.

Studies performed by Peng et al (Peng et al., 2022b), Augusto C et al (Augusto et al., 2020), A A silva et al (A. A. Silva et al., 2020), Gaya CS et al (Vieira et al., 2020c) and Xia Juan et al (Xia et al., 2020) evaluated the instrumentation efficacy in general than any particular mishap, thus were excluded.

Finally, a total of 13 articles were retrieved for the systematic review.

**Identification of studies via databases and registers**

Records identified from:

Databases (n =4)

PubMed=305

Cochrane= 71

EBSCO Host= 250

Google scholar= 26

Records removed *before screening*:

Duplicate records removed (n =12)

Records marked as ineligible by automation tools, literature reviews and case reports (n =14)

Irrelevant title/abstract (n=604)

**Identification**

Records screened

(n =652)

Records excluded\*\*

(n =630)

Reports sought for retrieval

(n =22)

Reports not retrieved

(n =1)

**Screening**

Reports excluded:

On artificial 3D printed teeth (n= 1)

On instrumentation/cleaning efficacy (n=5)

On voids in restoration (n=1)

On microcracks (n=1)

Reports assessed for eligibility

(n =21)

Studies included in review

(n =13)

Reports of included studies

(n =13)

**Included**

1. **Study Characteristics-**

Total 13 articles were retrieved, out of which 3 authors; McGuigan et al 2020 (McGuigan et al., 2013a), Gokhan Saygili et al 2018 (Saygili et al., 2018)and Rover G et al 2017(Rover et al., 2017) evaluated the impact of contracted endodontic access cavities on the incidences of missed canals. 4 authors; Corsentino et al 2021(Corsentino, 2021b), EJNL Silva et al 2020 (Emmanuel João Nogueira Leal Silva et al., 2020), dos Santos Miranda et al 2022(dos Santos Miranda et al., 2022b) and Spicciarelli V et al (Spicciarelli et al., 2020)assessed whether contracted access cavities increased the incidences of instrument fracture within the root canals. 6 authors; Mario Alviosi et al 2017(Alovisi et al., 2018b), AFA Barbosa et al 2020 (Barbosa et al., 2020b), C O Lima et al 2021(Lima et al., 2021b), Pereira et al 2021 (Pereira et al., 2021), Dan wang et al 2021 (Wang et al., 2021a), and Bayoumi A et al 2022 (Bayoumi et al., 2022)studied the impact of contracted endodontic cavities on the incidence of canal transportation.

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| Sr. no | Title, Author, year. | Population (P)  Teeth- | Intervention (I) | Comparator agent (C) | Outcome (O) | Authors remark | Database |
|  | Giacomo Corsentino et al,2021  (Corsentino, 2021a) | 60 Extracted human intact mandibular  molars | Root canal Instrumentation with Resciproc blue. | Truss Access cavity and traditional endodontic cavity. | Truss Access Cavity causes more fatigue of Reciproc  blueTM R25 than Conservative Access Cavity. | Contracted endodontic cavity increases the incidence of instrument separation. | Google scholar |
|  | Mario Alovisi et al;2017  (Alovisi et al., 2018a) | 30 Extracted humans  mandibular molars. | Root canal instrumentation done by ProGlider (Dentsply Maillefer, Ballaigues, Switzerland) and WaveOne Gold (Dentsply Maillefer). | Contracted endodontic cavity and traditional endodontic cavity. | TECs preserve the original canal anatomy during shaping when compared with CECs, particularly at the apical level. | Contracted endodontic access cavities increases the incidence of canal transportation, especially in the apical region. | Cochrane  Pubmed |
|  | Blauhut et al; 2020(“EBSCOhost | 150785246 | Reliability of root canal orifice assessments using minimally invasive access cavities.,” n.d.) | 84 extracted human molars | Conservative endodontic access cavity was prepared in each molar, and the teeth were evaluated independently by both students in the pair to determine the number and shape of the canal orifices. The access cavity was then extended to a traditional endodontic access cavity and independently evaluated again by the same persons. | Conservative endodontic cavity and traditional endodontic cavity. | The conservative endodontic access cavity approach is more susceptible to misinterpretation of the number and shape of canal orifices than the traditional approach. | Contracted endodontic access cavities increases the incidence of missed canals. | EBSCO host |
|  | Gokhan Saygili et al 2018. (Saygili et al., 2018) | 60 extracted human maxillary first molars. | Access cavity preparation and extra canal was searched. | Point EAC (PEAC), Conservative EAC (CEAC) and Traditional EAC (TEAC) | MB2 detection rate of CEAC (%53,3) and TEAC (%60) are higher than statistically that of PEAC (%31.6) | Contracted endodontic access cavities increases the incidence of missed canals. | PubMed |
|  | *A.F.A Barbosa et al;2020*(Barbosa et al., 2020b) | *30 extracted intact mandibular molars* | *Canals were initially prepared with Reciproc Blue R25 instrument followed by a second instrumentation using Reciproc Blue R40* | *Contracted endodontic cavity and traditional endodontic cavity.* | *No differences were found regarding transportation and centering ability* | *Contracted endodontic access cavities does not increase the incidence of canal transportation* | *PubMed* |
|  | C O Lima et al 2021. (Lima et al., 2021b) | 40 extracted mandibular molars | Biomechanical preparation with XP-endo shaper and Reciproc Blue. | Ultraconservative endodontic cavity and traditional endodontic cavity. | TradAC/XP had overall significantly less canal transportation | Contracted endodontic access cavities increases the incidence of canal transportation | PubMed |
|  | Gabriela Rover et al;2017(Rover et al., 2017) | 30 extracted intact maxillary first molars. | Access cavity preparation and 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.  Biomechanical preparation with reciproc blue. | Contracted endodontic cavity and traditional endodontic cavity. | It was possible to locate more root canals in the TEC group in stages 1 and 2 whereas no differences were observed after stage 3.  Canal transportation was significantly higher for the CEC group in the palatal canal at 7 mm from the apical end. | Contracted endodontic access cavities increases the incidence of missed canals, if not performed under microscope and ultrasonic troughing.  Contracted endodontic access cavities increases the incidence of canal transportation, especially in the apical region. | PubMed |
|  | Rodrigo Dantas et al; 2021(Pereira et al., 2021) | 90 upper premolars with a bifurcated root | Biomechanical preparation was done in the following groups (n=10) ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland), Reciproc (VDW GmbH, Munich, Germany), Reciproc Blue (VDW GmbH), and Hyflex EDM (Coltene/Whaledent, Altst€atten, Switzerland). | Contracted endodontic cavity and traditional endodontic cavity. | CECs had a negative impact on root canal centralization. Controlled memory instruments were the most adequate for the root canal preparation of CECs. | Contracted endodontic access cavities increases the incidence of canal transportation | Cochrane |
|  | *Dan Wang et al; 2021*(Wang et al., 2021a) | *30 extracted intact maxillary first molars* | *Biomechanical preparation was done.*  *Canal transportation and centring ratio were analysed* | *Traditional endodontic cavity (TEC) group, the conservative endodontic cavity (CEC) group and the guided endodontic cavity (GEC) group* | *The design of the endodontic access cavity did not impact on the effectiveness of canal instrumentation in terms of noninstrumented canal area, canal transportation and centring ratio.* | *CAC has no negative impact on instrumentation.* | *PubMed* |
|  | [Emmanuel João Nogueira Leal Silva](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Silva+EJNL&cauthor_id=33219876) et al; 2021(Emmanuel João Nogueira Leal Silva et al., 2020) | 40 human extracted mandibular molars | Biomechanical preparation with reciproc 25 blue and reciproc 25. | Traditional (TradAC) and ultraconservative (UltraAC) endodontic access  cavities | The use of R25B and R25 files in mandibular  molars with UltraACs decreased their cyclic fatigue resistance, compared with TradAC. | Contracted endodontic cavity increases the incidence of instrument separation. | PubMed |
|  | [*Ana Raquel Lopes Dos Santos Miranda*](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Dos+Santos+Miranda+ARL&cauthor_id=34561894) *et al; 2021*(dos Santos Miranda et al., 2022a) | *42 mandibular incisors with oval canals* | *Biomechanical preparation with wave one gold.* | *ultraconservative endodontic access cavity (UltraAC) and traditional access cavity (TradAC)* | *There was no difference in the flexural fatigue resistance of the instruments in relation to access cavity design.* | *Contracted endodontic cavity did not increase the incidence of instrument separation.* | *PubMed* |
|  | [Ahmed M. Bayoumi](https://journals.ekb.eg/?_action=article&au=478293&_au=Ahmed+M.+Bayoumi)et al 2022(Bayoumi et al., 2022) | 20 maxillary premolars | Mechanical preparation was done by Protaper Next files | Contracted endodontic cavity and traditional endodontic cavity. | TEC showed less transportation than CEC | Contracted endodontic access cavities increases the incidence of canal transportation | Cochrane |
|  | Valentina Spicciarelli et al 2020(Spicciarelli et al., 2020) | 40 maxillary central incisor teeth and 40 upper first premolars | Biomechanical preparation with reciproc blue R25 | Contracted endodontic cavity and traditional endodontic cavity. | Conservative Endodontic Cavity causes more cyclic fatigue of Reciproc blue R25 than Traditional Endodontic Cavity | Contracted endodontic cavity increases the incidence of instrument separation. | Google scholar |

**Results of included study-**

Figure 1- Percentage of studies mishap

Out of 13 studies included in this systematic review, 3 were on effects of CEC on instrument separation, 4 were on Incidence of missed canals and 6 were on Canal transportation. (Figure 1)

All the included studies were in-vitro studies performed on human extracted teeth. Different samples sizes were used for all the studies. (Figure2).

More weightage was given to the studies with larger sample size.

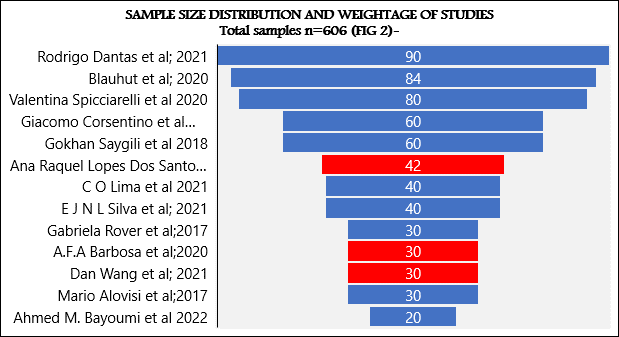
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Figure 2- Blue bars represent studies which concluded that contracted endodontic cavities increased the occurrence of endodontic mishaps.

*Red bars represent studies which concluded that contracted endodontic cavities have no effect on the occurrence of endodontic mishaps.*

*Studies with larger sample size were given more preference during the analysis.*

**Percent per sample-**

Missed canals

Canal transportation.

Figure 3- Total number of samples and occurrence of mishaps.

In the following systematic review, it Is seen that there is 100% increased incidence of missed canals due to the application of CEC, 81% increased incidence of Instrument separation and 75% increased occurrence of canal transportation.

Figure 4- Out of the 13 reviewed articles, 3 authors concluded that contracted endodontic cavities do not increase the incidence of endodontic mishaps, and 10 authors concluded that contracted endodontic cavities increased the incidences of endodontic mishaps.

**Discussion-**

Maintaining longevity of the tooth is the prime concern of a clinician. This can be effectively achieved by preserving maximum of healthy tooth structure. In endodontically treated teeth (ETT) the primary cause of tooth fracture is attributed to the loss of roof of pulp chamber for access preparation. Conventionally, the access preparation involved removal of extensive tooth structure; which allowed easy location of all the canals and straight line access to the apex, but this reduced the strength of the tooth. In recent times, contracted endodontic cavities (CEC) are practiced to preserve the roof of the pulp chamber or soffit (Clark and Khademi, 2010b) which acts as a support to the pericervical dentin thereby enhancing the fracture resistance of the tooth. Newer concept of the interaxial dentin, which is the dentin covering the pulp chamber roof is of significance in contracted endodontic cavity preparations. Preserving this dentin is directly proportional to the strength of the endodontically treated tooth.(“(PDF) Cavity configurations for in direct partial coverage adhesive-cemented restorations,” n.d.) The literature has revealed many studies(KISHEN, 2006; Plotino et al., 2017) supporting the doctrine of CEC increasing the fracture resistance of the endodontically treated teeth. Researchers and clinicians have also documented increased incidences of endodontic mishaps in teeth treated with the application of CEC. The common mishaps associated with CEC are missed canals and untreated root surface (due to incomplete deroofing), canal transportation and instrument separation (due to loss of straight-line access). Any untreated surface of the root canal may consist of infected pulp tissue, which may cause persistent periapical infection. (Ricucci et al., 2018; Siqueira and Lopes, 2001). These endodontic mishaps ultimately result in failure of treatment. The incidence of such failures reported due to missed canals; 100% increased incidence, fractured instrument; 81% increased incidence and Canal transportation; 75% increased incidence.

Shroff et al, have reported a Systematic review on instrumentation efficacy in CEC. However, there are fewer reviews reported on occurrence of endodontic mishaps associated with CEC. Thus, the authors have compiled a review on the above stated matter.

Various authors have reported dramatic variations in the shape, size and location of pulp chamber and root canals.(“Colleagues for Excellence Access Opening and Canal Location,” n.d.; Rusu et al., 2018) Al Fouzan et al in 2019 has reported 97% incidence of MB2s in maxillary first molar and 93% in maxillary second molars, further they concluded that only 70% MB2s (maxillary first molars) and 67% MB2s (maxillary second molars) were detected once the pulp chamber was exposed. Lack of good visibility and illumination is one of the major challenges in locating the canals/ missed canals, which compromises the healing process of periapical infection if any. (Costa et al., 2019b). Thus, a hypothesis could be formed that further contracting the cavities may increase the incidence of missed canals. To confirm this hypothesis, Blauhut et al; 2020 (“EBSCOhost | 150785246 | Reliability of root canal orifice assessments using minimally invasive access cavities.,” n.d.) in their experimental study concluded that contracted endodontic cavities are more susceptible in causing misinterpretation of number and shape of canals. In the present systematic review, it is seen that there are 100% increased chances of incidences of missed canals due to the contracted size of the endodontic cavities. Gokhan Saygili et al 2018(Saygili et al., 2018) and Gabriela Rover et al;2017(Rover et al., 2017)in their studies have also reported the corelation of contracted endodontic cavities and incidences of missed canals. The authors suggested that the incidences of missed canals in contracted endodontic cavities is mainly due to an inexperienced operator, lack of magnification and illumination.

According to American Association of endodontists, Glossary of endodontic terms, Canal transportation is the removal of the canal wall structure on the outside curve in the apical half of the canal due to the tendency of files to restore themselves to their original linear shape during canal preparation; may lead to ledge formation and possible perforation.(“American Association of Endodontists: Glossary of... - Google Scholar,” n.d.) When there is excessive removal of dentin from root canal wall in one direction only, canal transportation occurs. The possible sequelae of canal transportation are; damage to the apical foramina, zipping, elbow formation, perforation, strip perforation and ledging; all of these may compromise the root canal disinfection particularly at the apical third of the root canal, thus causing root canal failure.(SCHÄFER and DAMMASCHKE, 2006) A straight line access is desirable for safe and efficient instrumentation, Jafarzadeh H et al in 2017(Jafarzadeh and Abbott, 2007) reported that insufficiently designed access cavity leads to improper guiding of the instrument by the cavity wall and causes loss of control of instrument during root canal instrumentation. Mario Alovisi et al in 2018(Alovisi et al., 2018a)in their in-vitro study on 30 extracted human mandibular molars reported that root canal instrumentation done with Traditional endodontic cavities showed greater preservation of original root canal geometry when compared with contracted endodontic cavities. AFA Barbosa et al in 2020(Barbosa et al., 2020b) performed a micro-CT study on 30 extracted mandibular molars concluded that root canals prepared with the application of contracted endodontic cavities had more unprepared canal surfaces when compared with root canals prepared with traditional endodontic cavities, but there was no evidence of increased incidence of canal transportation.

In the present review, it is seen that there are 75% increased incidence of canal transportation with the application of contracted endodontic cavities.

Gabriella Rover et al 2017 et al(Rover et al., 2017) reported pronounced canal transportation in palatal canal at 7mm from apex with application of contracted endodontic cavities when compared with traditional access cavities. TEC group showed lesser canal transportation probably because of the straight-line access. Pereira R et al (2021)(Pereira et al., 2021) in their in-vitro study on 90 upper premolars reported many negative effects of Contracted endodontic cavities on root canal centralization, uncleaned canal surfaces, percentage of voids in restoration and cleaning of the pulp chamber. This was imparted to the contracted size of the cavity. On the contrary, Wang D et al (2021)(Wang et al., 2021a) compared TEC and CEC; evaluated the volume of dentin removed in the both the situations and reported that more volume of pericervical dentin was removed in TEC when compared with CEC; but there was no significant difference in instrument separation, non-instrumented canal surfaces and canal transportation. Explanation to this result is that the instruments used in this study were of great flexibility that could adapt the root canal morphology and perform adequate apical enlargement. Moreover, all the procedures were performed by specialised endodontics with minimum of 10 years’ experience and under 17X magnification. It could be summarised that there are many factors influencing canal transportation, including the metallurgy, dimension, and design of the instrument along with the way the instrument is used.

Another common mishap which was prevalent with contracted endodontic cavities is instrument separation. Endodontic instruments fracture in the root canal due to two reasons, flexural fatigue, and torsional fracture.(McGuigan et al., 2013b) Flexural fracture is known to occur essentially when the metal alloy is overused, while torsional fractures are a result of torsional overload. Achieving a straight-line access is paramount in avoiding instrumentation accidents. But, in cases of contracted endodontic cavities straight line access is not achieved and this fact may lead to the increased incidence of instrument fracture. The prognosis of a tooth with separated instrument automatically decreases as there are uncleaned canal surfaces, where the microorganisms have not been eliminated. Spicciarelli V et al (2020)(Spicciarelli et al., 2020)and Silva E et al (2021)(Emmanuel João Nogueira Leal Silva et al., 2020) in their experimental study on extracted maxillary central incisors reported that CEC caused more cyclic fatigue on endodontic instruments. Truss access cavities impart even more torsional overload on endodontic instruments. (Corsentino, 2021b) On contrary, another experimental study on mandibular incisors with oval canals, performed to evaluate the incidence of instrument separation due to CEC concluded that there was no significant difference in flexural fatigue resistance of instruments due to the access cavity design. It was reported that regardless of the size of the access cavity, if a straight-line access is established to the apex of the root canals, there will be no torsional overload on the endodontic instruments due to the access cavity shape.(dos Santos Miranda et al., 2022b) In the above systematic review it is seen that there are 81.1% increased incidences of instrument separation in CEC. The goal of endodontic treatment is to eliminate all the microorganisms from the root canal system and seal it to avoid any further infection or re-infection. Endodontic mishaps caused, can cause compromised cleaning and shaping of the canal; thus, increasing the chances of failures.

**Conclusion-** In the above systematic review, it is seen that there is 100% increase in the incidence of missed canals, 81.08 % increase in the incidence of instrument separation within the canal and 75% increase in the canal transportation. Thus, contracted endodontic cavities, proven to reduce the volume of dentin removed, but this may or may not be of advantageous for the biomechanical properties of the endodontically treated tooth. The contracted size of the cavity; increases incidences if endodontic mishaps in CEC’s. There should be a balance between the application of contracted endodontic cavities and root canal instrumentation to avoid mishaps, as the main aim of a root canal treatment is to eliminate all the microbes and seal all the portals of the root canal system. It is always wise to extend the endodontic access cavity in order to remove the infected tissue. One must have adequate experience and knowledge about the location and number of the canals; along with magnification, isolation, ultrasonics to avoid endodontic mishaps in contracted endodontic cavities.

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