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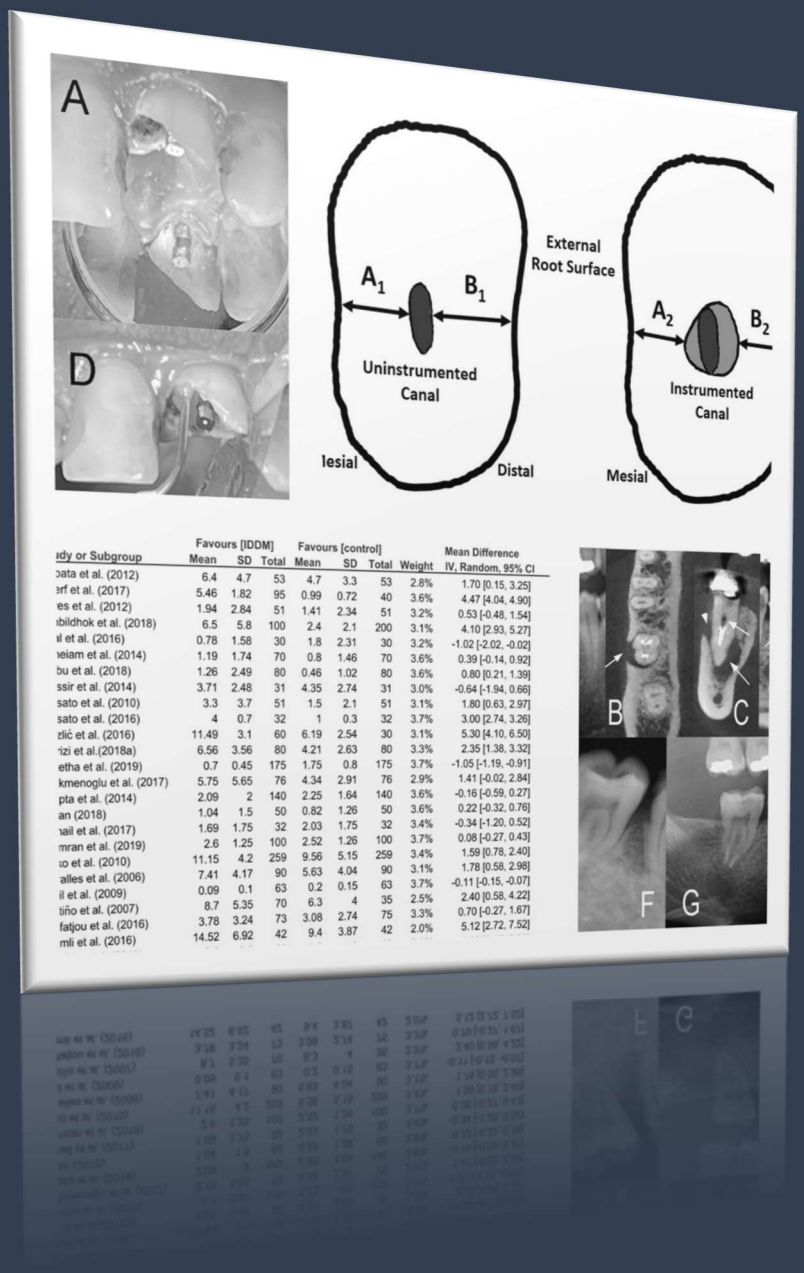


| dy or Subgroup | Favours [IDDM] Mean | SD | Total | Favours [control] Mean | SD | Total | Weight | Mean Difference IV, Random, 95% CI |
|---|---|---|---|---|---|---|---|---|
| ɔata et al. (2012) | 6.4 | 4.7 | 53 | 4.7 | 3.3 | 53 | 2.8% | 1.70 [0.15, 3.25] |
| ərf et al. (2017) | 5.46 | 1.82 | 95 | 0.99 | 0.72 | 40 | 3.6% | 4.47 [4.04, 4.90] |
| es et al. (2012) | 1.94 | 2.84 | 51 | 1.41 | 2.34 | 51 | 3.2% | 0.53 [-0.48, 1.54] |
| ıbildhok et al. (2018) | 6.5 | 5.8 | 100 | 2.4 | 2.1 | 200 | 3.1% | 4.10 [2.93, 5.27] |
| ıl et al. (2016) | 0.78 | 1.58 | 30 | 1.8 | 2.31 | 30 | 3.2% | -1.02 [-2.02, -0.02] |
| ıeiam et al. (2014) | 1.19 | 1.74 | 70 | 0.8 | 1.46 | 70 | 3.6% | 0.39 [-0.14, 0.92] |
| bu et al. (2018) | 1.26 | 2.49 | 80 | 0.46 | 1.02 | 80 | 3.6% | 0.80 [0.21, 1.39] |
| ssir et al. (2014) | 3.71 | 2.48 | 31 | 4.35 | 2.74 | 31 | 3.0% | -0.64 [-1.94, 0.66] |
| sato et al. (2010) | 3.3 | 3.7 | 51 | 1.5 | 2.1 | 51 | 3.1% | 1.80 [0.63, 2.97] |
| sato et al. (2016) | 4 | 0.7 | 32 | 1 | 0.3 | 32 | 3.7% | 3.00 [2.74, 3.26] |
| zlić et al. (2016) | 11.49 | 3.1 | 60 | 6.19 | 2.54 | 30 | 3.1% | 5.30 [4.10, 6.50] |
| rizi et al.(2018a) | 6.56 | 3.56 | 80 | 4.21 | 2.63 | 80 | 3.3% | 2.35 [1.38, 3.32] |
| etha et al. (2019) | 0.7 | 0.45 | 175 | 1.75 | 0.8 | 175 | 3.7% | -1.05 [-1.19, -0.91] |
| kmenoglu et al. (2017) | 5.75 | 5.65 | 76 | 4.34 | 2.91 | 76 | 2.9% | 1.41 [-0.02, 2.84] |
| pta et al. (2014) | 2.09 | 2 | 140 | 2.25 | 1.64 | 140 | 3.6% | -0.16 [-0.59, 0.27] |
| an (2018) | 1.04 | 1.5 | 50 | 0.82 | 1.26 | 50 | 3.6% | 0.22 [-0.32, 0.76] |
| ıail et al. (2017) | 1.69 | 1.75 | 32 | 2.03 | 1.75 | 32 | 3.4% | -0.34 [-1.20, 0.52] |
| mran et al. (2019) | 2.6 | 1.25 | 100 | 2.52 | 1.26 | 100 | 3.7% | 0.08 [-0.27, 0.43] |
| ɔ et al. (2010) | 11.15 | 4.2 | 259 | 9.56 | 5.15 | 259 | 3.4% | 1.59 [0.78, 2.40] |
| alles et al. (2006) | 7.41 | 4.17 | 90 | 5.63 | 4.04 | 90 | 3.1% | 1.78 [0.58, 2.98] |
| il et al. (2009) | 0.09 | 0.1 | 63 | 0.2 | 0.15 | 63 | 3.7% | -0.11 [-0.15, -0.07] |
| tiño et al. (2007) | 8.7 | 5.35 | 70 | 6.3 | 4 | 35 | 2.5% | 2.40 [0.58, 4.22] |
| fatjou et al. (2016) | 3.78 | 3.24 | 73 | 3.08 | 2.74 | 75 | 3.3% | 0.70 [-0.27, 1.67] |
| mli et al. (2016) | 14.52 | 6.92 | 42 | 9.4 | 3.87 | 42 | 2.0% | 5.12 [2.72, 7.52] |

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## Editorial Board

# EndoRes

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## Aims & Scope

Journal of Endodontics and Restorative Dentistry (J Endod Restor Dent) is a highly respected scientific journal that caters to the needs of those interested in the fields of endodontics and restorative dentistry. This online-only journal follows a rigorous and independent peer-review process, ensuring that all articles are unbiased and of the highest quality. The double-blinded approach employed by Journal of Endodontics and Restorative Dentistry further strengthens its credibility, making it a trusted source of information for researchers, practitioners, and students alike. With its biannual release schedule, readers can look forward to two new issues each year, in March and September. Overall, Journal of Endodontics and Restorative Dentistry is a valuable resource for anyone seeking to stay up-to-date on the latest developments in these important areas of dental science.

Journal of Endodontics and Restorative Dentistry provides extensive coverage of both clinical and experimental studies on all aspects of endodontics and restorative dentistry. Notably, the journal features original articles, reviews on current topics, case reports, editorial comments, and letters to the editor that follow ethical guidelines. It is important to note that the journal is published solely in English, ensuring it maintains a global reach and fosters international collaboration within the field.

The journal's editorial and publication processes are meticulously designed to meet the highest standards of integrity and quality. To ensure this, the journal adheres to the guidelines set by several reputable organizations such as the International Committee of Medical Journal Editors (ICMJE), World Association of Medical Editors (WAME), Council of Science Editors (CSE), Committee on Publication Ethics (COPE), European Association of Science Editors (EASE), and National Information Standards Organization (NISO). Furthermore, the journal is committed to upholding the Principles of Transparency and Best Practice in Scholarly Publishing, which have been laid out by the Directory of Open Access Journals (DOAJ) at doaj.org/bestpractice.

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## Table of Contents

### Original Articles



### Case Reports

JOURNAL of ENDODONTICS and RESTORATIVE DENTISTRY

Original Article

# The Relationship between Insulin-dependent Diabetes Mellitus (Type 1 Diabetes) and Dental Caries: A Meta-Analysis

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CLINICAL SIGNIFICANCE

Individuals with insulin diabetes mellitus may be at an elevated risk of experiencing dental caries in their permanent teeth. Due to this increased susceptibility, healthcare professionals must exercise additional caution when treating and caring for these patients.

ABSTRACT

**Objectives**: The objective of this study was to perform a meta-analysis by combining the findings of studies that examined the link between insulin-dependent diabetes mellitus (IDDM) and dental caries in both permanent as well as deciduous teeth.

**Materials and Methods:** The PRISMA statement guide was utilized in order to conduct a thorough meta-analysis. This involved conducting searches across electronic databases to select relevant studies, as well as collecting pertinent data. A comprehensive evaluation of biases was also performed, both on an individual and collective level. For the purposes of comparing results, mean differences (MD) were implemented as the primary metric for measuring effect estimates.

**Results:** The study consisted of 42 qualitative and 32 quantitative analyses. The DMFT score was significantly higher in the IDDM group compared to the control group (MD=1.24, CI: 0.74,1.74; p<0.001), but there was no significant difference in the dmft score (MD=-0.40, 95% CI: -0.82, 0.02; p=0.06). The statistical outcomes for DMFT ($Tau^2$=1.75, $Chi^2$=1420.50, $I^2$=98%, p<0.001) and dmft ($Tau^2$=0.36, $Chi^2$=75.01, $I^2$=84%, p<0.001) showed considerable heterogeneity.

**Conclusion:** Research suggests that individuals with IDDM may have an increased risk of developing dental caries in their permanent teeth. However, this association between IDDM and dental caries does not appear to be present in deciduous teeth.

## 1. Introduction

Diabetes mellitus (DM) is a widely prevalent metabolic disorder that is characterized by hyperglycemia and numerous complications. This disease encompasses four types: Type 1 or insulin-dependent diabetes (IDDM), type 2 or non-insulin-dependent diabetes (NIDDM), gestational diabetes, and specific types (e.g., maturity onset diabetes of the young).[1] IDDM is a complex autoimmune disorder that results in the deficient production of insulin from pancreatic beta cells. It is more commonly diagnosed in children and adolescents, with the highest incidence occurring during puberty. The clinical manifestations of IDDM are complex and involve numerous complications associated with hyperglycemia. This can lead to damage to various organs, such as the kidneys, retina, and nerves that have capillary vessels. The consequences of this disease can be severe and long-lasting, which is why it is critical to manage DM properly to avoid or minimize its complications.[2]

According to recent research[3-5], there appears to be a connection between the secretion of saliva and the onset of various metabolic disorders. Capillaries are small blood vessels that are present in various tissues throughout the body, including the oral tissues. Individuals who suffer from IDDM may experience complications in their oral tissues in addition to other organs. Complications may arise in various ways, such as a reduction in salivary flow rate, which can lead to dental caries and periodontal diseases.[4,6] The effects of IDDM on the oral tissues can be attributed to several factors, including different dietary habits of IDDM patients, alterations in salivary flow rate, and variations in saliva composition. These factors can lead to changes in the oral microflora, potentially linking IDDM to dental caries. It is important to address these complications early on to prevent more severe oral health issues from developing.[7]

Over the years, researchers have conducted several studies to investigate the correlation between IDDM and oral complications, particularly dental caries. However, dental caries is a complex disease that is influenced by various factors such as lifestyle, diet, and oral hygiene, among others. This has resulted in inconsistencies in the findings of previous studies that have attempted to establish a link between dental caries and IDDM.[8-13] Therefore, the primary objective of this study is to conduct a comprehensive analysis of both qualitative and quantitative outcomes of past research in order to provide a conclusive report on the impact of IDDM on dental caries.

## 2. Materials and Methods

### 2.1. Guidance and Eligibility criteria

This meta-analysis adhered to the guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[14] The inclusion criteria of the studies were (1) Studies which investigated dental caries in the primary or permanent dentition, (2) Studies which presented DMFT/dmft or DMFS/dmfs or DFS/dfs as caries indexes clearly, (3) Studies which investigated IDDM population (NIDDM was not included), (4) Observational studies. The exclusion criteria of the studies were (1) Studies which did not include a healthy subject (control) group, (2) Studies which combined IDDM and NIDDM population, (3) Studies which did not report standard deviations (Although their primer outcome was continuous), (4) Studies which combined dental caries scores, (5) Studies which did not report caries index values clearly, (6) Studies in which the full text could not be found, (7) Short communication, review, case report or case series (8) Language of publication other than English. We did not impose

any restrictions with respect to time of publication, sex, or age.

In order to establish the parameters for the studies that were deemed appropriate for inclusion, we utilized the PICOs models as outlined below.

Population (P): Healthy individuals and those with IDDM
Indicator (Cases) (I): DMFT, dmft of individuals with IDDM
Comparison (Control) (C): DMFT, dmft of healthy individuals
The outcome (O): Association with the presence of IDDM
Study design (S): Observational studies

### 2.2. Information sources and search strategy

In June 2019, one of the researchers (T.S.) searched through electronic databases including Web of Science, PubMed, Scopus, Cochrane Library, and Open Grey Databases. The search strategies used can be found in Table 1. Two authors (S.S. and A.M) also carefully looked through the reference lists of the gathered papers and reviews to find any additional studies. Additionally, the authors accessed recent articles that referenced the obtained studies.

### 2.3. Study selection and data collection process

Two independent analysts (S.S and A.M) evaluated the titles and abstracts of the studies we obtained. To eliminate duplicate references, we used a reference management software (EndNote® X9 Thomson Reuters, Philadelphia, PA, USA). We also reached out to authors to obtain texts of studies that didn't allow full-text access. The final decision on which studies to include in the meta-analysis was unanimous among the two reviewers (S.S. and A.M).

### 2.4. Risk of bias in individual studies

To determine the risk of bias in the study, the Joanna Briggs Institute Critical Appraisal Checklist was employed, which is specially designed for cross-sectional studies.[15] Two independent reviewers, namely S.S. and A.M., conducted the assessment and arrived at a consensus. In case of any disagreements, they consulted a third author, T.S. The Joanna Briggs guidelines were adhered to for scoring and established cutoff points to classify studies into different risk of bias categories. Studies with up to 49% of questions scored as "yes" were deemed to have a high risk of bias, those with scores ranging from 50 to 69% as moderate risk, while those with more than 70% as low risk.

### 2.5. Summary Measures

The primary outcome parameters of interest were “DMFT” and “dmft”. Mean differences (MD) and its respective 95% confidence intervals (95% CI) were used in measuring the effect estimate in the comparisons.

### 2.6. Synthesis of results

The meta-analysis software of the Cochrane Collaboration (RevMan 5.3, The Nordic Cochrane Centre, Copenhagen, Denmark) was used to estimate the overall effects and to produce the forest plots. The level of significance was set at $p < 0.05$.

### 2.7. Risk of bias across studies

To assess clinical heterogeneity, we compared the variations between cases, controls, and study outcomes. We utilized Chi-squared, Tau-squared, and Higgins $I^2$ tests to evaluate statistical heterogeneity. The $I^2$ statistic was used to measure heterogeneity among the studies, and was classified as follows: less than 30% was considered insignificant, 30% to 50% was moderate, 50% to 75% was substantial, and 75% to 100% was considerable. We opted for the random effects model with 95% confidence intervals as the meta-analysis model, due to the presence of heterogeneity among studies.

### 2.8. Sensitivity Analysis

To assess the strength of the combined findings, a sensitivity analysis was carried out using the leave-one-out methodology.

### 2.9. Publication Bias

To assess publication bias, we employed the Egger Regression statistical analyses and Funnel Plot. We visually inspected the funnel plots to evaluate the risk of bias across studies and tested their asymmetry using Egger's test.

### 2.10. Grade Analysis

To rate the quality of evidence and the strength of recommendations, we utilized the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) system. We developed a summary of findings (SoF) table with the help of the GRADE Working Group's online software, GRADEpro GDT.[16]

## 3. Results

### 3.1. Study Selection

The parameters mentioned earlier were used to scan the databases, resulting in a total of 39963 records. These records were obtained from various sources, such as Pubmed (n= 1867), Web of Science (n= 1304), Scopus (n= 36765), Cochrane Library (n= 18), and Open Grey (n= 9). After eliminating repetitive studies, the number was reduced to 7032. These studies were then screened, and only 124 were left after title and abstract screening. After thoroughly reviewing the remaining studies, 82 more were excluded due to eligibility criteria. Finally, 42 cross-sectional studies were included in the qualitative synthesis (Fig 1). All the references of the included studies can be found in Appendix 1.

### 3.2. Risk of bias within studies

Out of the 19 studies reviewed, 16 were deemed to have low risk of bias while the remaining 3 were classified as high risk. However, when it came to assessing whether confounding factors were identified and strategies to address them were stated (questions 5

**Table 1.** Search strategies employed in different information databases

| Database | Search strategy |
|---|---|
| **PubMed** | ((Diabetes Mellitus) OR (Diabetes Complications) OR (Type 1 Diabetes Mellitus) OR (Type 1 Diabetes) OR (Diabetes Mellitus, Insulin-Dependent) OR (Insulin-dependent Diabetes Mellitus)) AND ((Dental Caries) OR (Dental Caries Susceptibility) OR (Cariogenic Bacteria) OR (decay) OR (caries)) |
| **Web of Science** | TS=((Diabetes Mellitus OR Diabetes Complications OR Type 1 Diabetes Mellitus OR Type 1 Diabetes OR Diabetes Mellitus, Insulin-Dependent OR Insulin-dependent Diabetes Mellitus) AND (Dental Caries OR Dental Caries Susceptibility OR Cariogenic Bacteria OR decay OR caries)) |
| **Scopus** | ( ( diabetes AND mellitus ) OR ( diabetes AND complications ) OR ( type 1 diabetes AND mellitus ) OR ( type 1 diabetes ) OR ( diabetes AND mellitus, AND insulin-dependent ) OR ( insulin-dependent AND diabetes AND mellitus ) ) AND ( ( dental AND caries ) OR ( dental AND caries AND susceptibility ) OR ( saliva ) OR ( cariogenic AND bacteria ) OR ( decay ) OR ( caries ) ) |
| **Cochrane Library** | #1 ("diabetes mellitus type 1") AND ("dental caries") |
| **Open Grey** | ((Diabetes Mellitus) OR (Diabetes Complications) OR (Type 1 Diabetes Mellitus) OR (Type 1 Diabetes) OR (Diabetes Mellitus, Insulin-Dependent) OR (Insulin-dependent Diabetes Mellitus)) AND ((Dental Caries) OR (Dental Caries Susceptibility) OR (Cariogenic Bacteria) OR (decay) OR (caries)) |

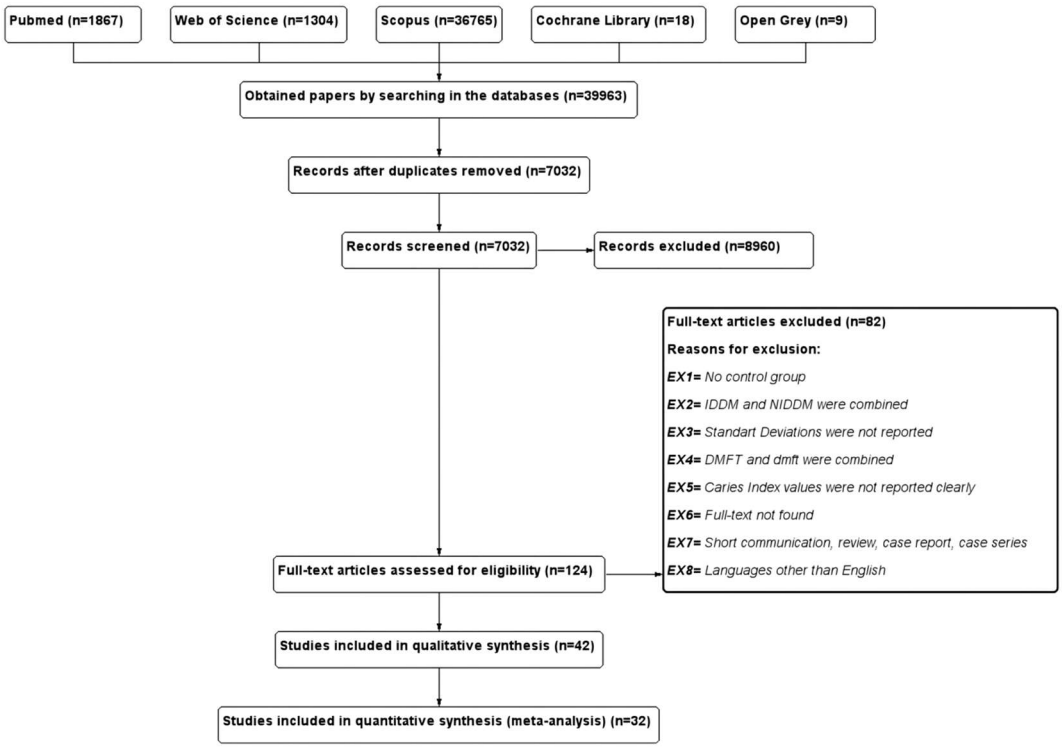


**Fig. 1.** Flow diagram of the studies involved in the qualitative and quantitative analyses

and 6, respectively), most studies were found to have high risk of bias. On the other hand, with regards to the 8th question regarding the use of appropriate statistical analysis, almost all studies were considered to have low risk of bias (Table 2).

### 3.3. Results of Individual Studies

DMFT scores were significantly higher in IDDM populations compared to control groups in 14 out of 32 studies ($p<0.05$). However, in 2 studies, the control group had significantly higher DMFT scores ($p<0.05$). In terms of dmft index, dental caries scores were lower in 3 studies and higher in 2 studies compared to control groups ($p<0.05$). In 3 out of 11 studies, IDDM populations had significantly higher dental caries scores than control groups based on DMFS index ($p<0.05$), but no association was found in the others ($p>0.05$). In 2 out of 5 studies using dmfs index, control groups had significantly higher dental caries scores than IDDM populations ($p<0.05$). In terms of DFS index, control groups had significantly higher dental caries scores in 2 studies and lower scores in 1 study compared to IDDM populations. However, no significant association was found for dfs index ($p>0.05$) (Appendix 1).

### 3.4. Synthesis of Results

The IDDM group had a significantly higher DMFT score than the control group (MD=1.24, 95% CI: 0.74, 1.74; $p<0.001$). Fazlić, et al. [12] found the highest mean difference (MD = 5.3, 95% CI: 4.10, 6.50)

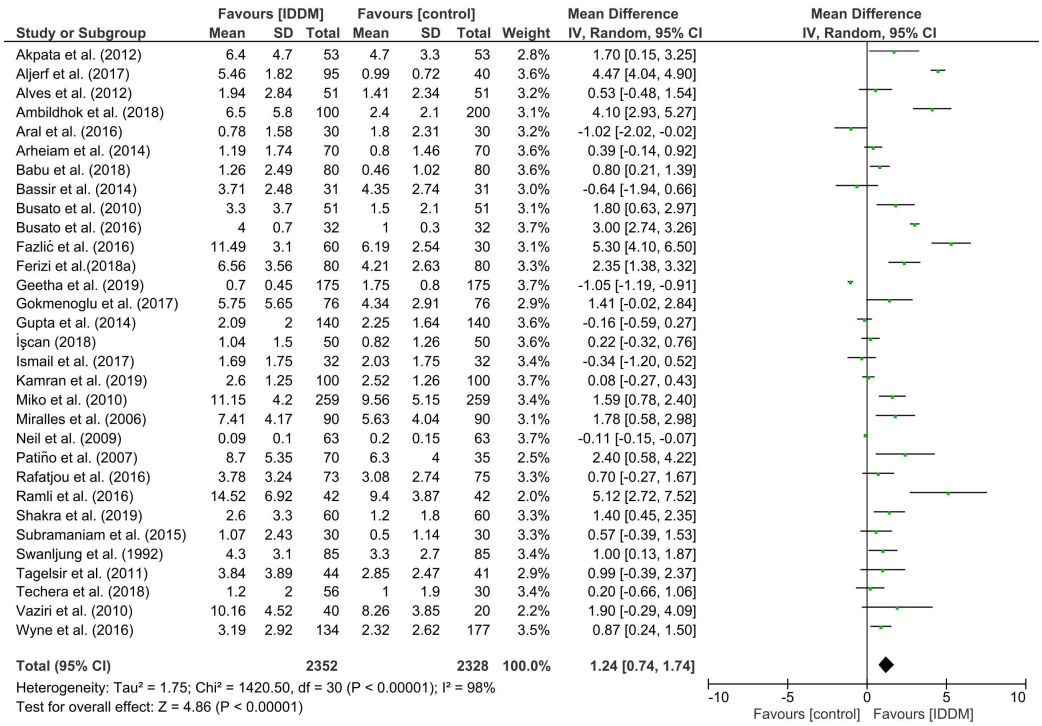


**Fig. 2.** Forest plot presentations of DMFT outcomes

in favor of the IDDM group (Fig 2). While the control group had a tendency towards a higher dmft score, there was no significant difference observed between the IDDM and control groups (MD=-0.40, 95% CI: -0.82, 0.02; p=0.06). Rafatjou, et al. [17] found the highest mean difference (MD=-2.84, 95% CI: -4.48, -1.20) in favor of the control group (Fig 3).

### 3.5. Risk of Bias Across Studies

Various studies showed serious heterogeneities in the methods used to diagnose and treat diabetes, as well as in the clinical parameters such as gender, age, and duration of diabetes. Furthermore, there were considerable heterogeneities in the statistical outcomes of DMFT ($Tau^2$=1.75, $Chi^2$=1420.50, $I^2$=98%, p<0.001) and dmft ($Tau^2$=0.36, $Chi^2$=75.01, $I^2$=84%, p<0.001). Therefore, a random effects model was utilized in all quantitative analyses to account for these considerable heterogeneities.

### 3.6. Sensitivity Analysis

Our research involved conducting sensitivity analyses for all outcomes. Specifically, for the DMFT outcome, we removed studies with a high risk of bias and found that the estimates remained similar (MD=1.16, 95% CI: 0.66, 1.67; p<0.001). We then proceeded to remove studies with high and moderate risk of bias and still observed similar estimates (MD = 1.12, 95% CI: 0.03, 2.21; p = 0.04), albeit with a slight reduction in the effect. For the dmft outcome, we removed studies with high and moderate risk of bias, which resulted in a significantly decreased estimate (MD = -0.26, 95% CI: -1.03, 0.50; p = 0.50). For a more detailed analysis, please refer to Appendix 2.

### 3.7. Publication Bias

The analysis of DMFT outcome using funnel plot revealed a possible publication bias, as observed through visual evaluation.

**Table 2.** Risk of bias summary, assessed by Joanna Briggs Institute Critical Appraisal Checklist for Cross-sectional (n=42): author's judgments for each included study

| Author | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Total | Risk of Bias |
|---|---|---|---|---|---|---|---|---|---|---|
| Akpata et al. (2012) | N | Y | Y | Y | Y | Y | Y | Y | 87.5% | Low |
| Aljerf et al. (2017) | U | Y | Y | Y | Y | N | Y | Y | 75% | Low |
| Al-Khayoun et al. (2013) | Y | Y | Y | Y | N | N | U | Y | 62.5% | Moderate |
| Al-Rawi et al. (2010) | N | Y | Y | Y | N | N | U | Y | 50% | Moderate |
| Alves et al. (2012) | U | Y | Y | Y | Y | N | Y | Y | 75% | Low |
| Ambildhok et al. (2018) | Y | Y | Y | Y | Y | Y | N | Y | 87.5% | Low |
| Aral et al. (2016) | Y | Y | Y | Y | N | N | U | Y | 62.5% | Moderate |
| Arheiam et al. (2014) | Y | U | Y | Y | N | N | Y | Y | 62.5% | Moderate |
| Babu et al. (2018) | Y | U | Y | Y | N | N | Y | Y | 50% | Moderate |
| Bassir et al. (2014) | N | U | Y | Y | Y | Y | Y | Y | 62.5% | Moderate |
| Busato et al. (2010) | Y | Y | Y | Y | N | N | U | Y | 62.5% | Moderate |
| Busato et al. (2016) | Y | U | Y | Y | N | N | U | Y | 50% | Moderate |
| El-Tekeya et al. (2012) | Y | Y | Y | Y | Y | Y | U | Y | 87.5% | Low |
| Fazlić et al. (2016) | Y | N | Y | Y | N | N | Y | Y | 62.5% | Moderate |
| Ferizi et al. (2018) | Y | N | Y | Y | Y | Y | Y | Y | 87.5% | Low |
| Geetha et al. (2019) | Y | Y | Y | Y | Y | Y | Y | Y | 100% | Low |
| Gokmenoglu et al. (2017) | Y | U | Y | Y | Y | Y | Y | Y | 87.5% | Low |
| Gupta et al. (2014) | N | U | Y | Y | N | N | Y | Y | 50% | Moderate |
| İşcan (2018) | Y | Y | Y | Y | Y | Y | Y | Y | 100% | Low |
| Ismail et al. (2017) | Y | Y | Y | Y | Y | U | Y | Y | 87.5% | Low |
| Kamran et al. (2019) | N | U | Y | Y | Y | Y | Y | Y | 75% | Low |
| Matsson et al. (1975) | Y | N | U | Y | N | N | U | U | 25% | High |
| Miko et al. (2010) | Y | N | Y | Y | N | N | U | Y | 50% | Moderate |
| Miralles et al. (2006) | Y | N | Y | Y | U | U | U | Y | 50% | Moderate |
| Moore et al. (2001b) | U | Y | U | N | Y | Y | U | Y | 50% | Moderate |
| Neil et al. (2009) | N | N | Y | Y | Y | N | N | Y | 50% | Moderate |
| Orbak et al. (2008) | Y | Y | Y | Y | N | N | Y | Y | 75% | Low |
| Patiño et al. (2007) | Y | Y | Y | Y | N | N | Y | Y | 75% | Low |
| Rafatjou et al. (2016) | Y | U | Y | Y | Y | N | Y | Y | 75% | Low |
| Ramli et al. (2016) | Y | N | U | Y | N | N | N | Y | 37.5% | High |
| Sadeghi et al. (2017) | Y | U | Y | Y | Y | N | N | Y | 62.5% | Moderate |
| Shakra et al. (2019) | U | U | Y | Y | N | N | Y | Y | 37.5% | High |
| Singh-Hüsgen et al. (2016) | Y | U | Y | Y | N | N | Y | Y | 62.5% | Moderate |
| Siudikiene et al. (2006) | N | N | U | Y | Y | Y | U | Y | 50% | Moderate |
| Subramaniam et al. (2015) | Y | U | Y | Y | N | N | Y | Y | 62.5% | Moderate |
| Swanljung et al. (1992) | N | N | Y | Y | N | N | Y | Y | 50% | Moderate |
| Tagelsir et al. (2011) | Y | Y | Y | Y | Y | Y | Y | Y | 100% | Low |
| Techera et al. (2018) | Y | Y | Y | Y | N | N | Y | Y | 75% | Low |
| Tenovuo et al. (1986) | N | Y | Y | Y | N | N | Y | Y | 62.5% | Moderate |
| Vaziri et al. (2010) | Y | Y | Y | Y | N | N | U | Y | 62.5% | Moderate |

Legend: Y= Yes; N= No; U= Unclear; Cross-Sectional Study Checklist: Q1- Were the criteria for inclusion in the sample clearly defined? Q2- Were the study subjects and the setting described in detail? Q3- Was the exposure measured in a valid and reliable way? Q4- Were objective, standard criteria used for measurement of the condition? Q5- Were confounding factors identified? Q6- Were strategies to deal with confounding factors stated? Q7- Were the outcomes measured in a valid and reliable way? Q8- Was appropriate statistical analysis used? Total= ΣY/Applicable Items. Risk of bias was categorized as high when the study reaches up to 49% score "yes", moderate when the study reached 50% to 69% score "yes", and low when the study reached more than 70% score "yes.

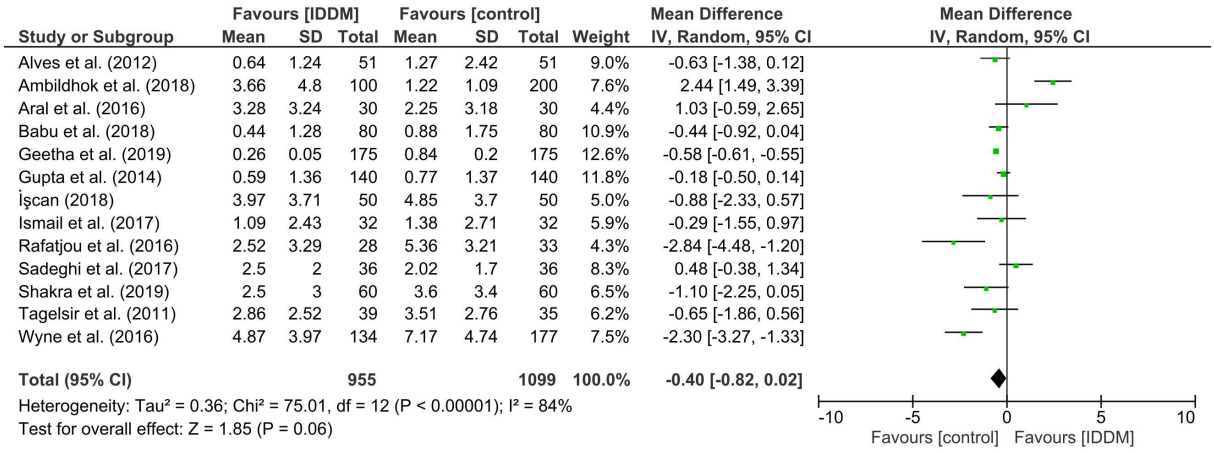


**Fig. 3.** Forest plot presentations of dmft outcomes

This impression was further supported by Egger's test, indicating significant results for DMFT (p<0.001). However, in dmft analysis, no such bias was observed (p=0.715). The funnel plots can be found in Fig 4.

### 3.8. Grade Analysis

For the outcome of DMFT, one rating down was applied due to moderate risk of bias among most studies. All outcomes showed inconsistencies, resulting in a one point rating down. For DMFT outcomes, potential bias was suspected based on Egger regression analyses and Funnel plot examination, leading to another rating down. Overall, the GRADE criteria classified the confidence in cumulative evidence assessment as very low for all outcomes (Fig 5).

## 4. Discussion

IDDM, or insulin-dependent diabetes mellitus, is a metabolic disease that is widely prevalent and can have detrimental effects on vascular tissues due to its ability to cause hyperglycemia. These effects can also manifest in small vessels present in oral tissues, leading to microangiopathy.[18] Given the significant implications of IDDM on oral health, researchers have taken a keen interest in investigating the impact of the disease on oral tissues.[6]

Individuals with IDDM are often advised by their healthcare providers to adhere to a specific dietary plan on a daily basis. This is because various studies have demonstrated that following such a plan can help reduce sugar intake, which, in turn, can significantly lower the risk of developing dental cavities.[11,19] However, adhering to ideal dietary limitations may not always be feasible for IDDM patients due to various factors such as geographical location, age, gender, and level of education within the family.[20] For instance, a global study conducted on sugar consumption in the form of sugary beverages revealed that North America had the highest sugar intake, while Asia had the lowest.[21] This suggests that regional differences in sugar intake can have a considerable impact on the risk of developing cavities for IDDM patients. Age is also a crucial factor that plays a vital role in IDDM patients' dietary habits, with older adults usually consuming less sugar. A survey conducted on adults aged 20 to 70 found that older adults tend to consume less sugar than their younger counterparts.[21] Multiple factors such as age, gender, and geographical region can contribute to heterogeneity in the analysis of IDDM patients' dietary habits, thereby potentially complicating the management of the condition. In conclusion, while adhering to a specific dietary plan can lower the risk of developing cavities for IDDM patients, various factors can influence their dietary habits, making the management of the condition more challenging.

The findings of this particular study have shed light on a concerning increase in caries rates among IDDM patients, which was determined based on the DMFT index. Interestingly, a slight decrease was observed in the dmft index, but it was not significant. The reasoning behind this phenomenon could be attributed to parental overprotection, which may help mitigate some of the negative oral health impacts of IDDM on deciduous teeth. With the implementation of proper dietary restrictions, it's possible that IDDM patients may actually experience fewer dental caries than healthy individuals. However, the duration of diabetes may also play a significant role in this matter. Other studies have shown that individuals with longer-term diabetes had a higher incidence of dental caries than those with shorter durations.[22,23] It's also worth noting that deciduous teeth may be less prone to being affected by DM when compared to permanent teeth. Nonetheless, the significance of the relationship between dental caries and IDDM in

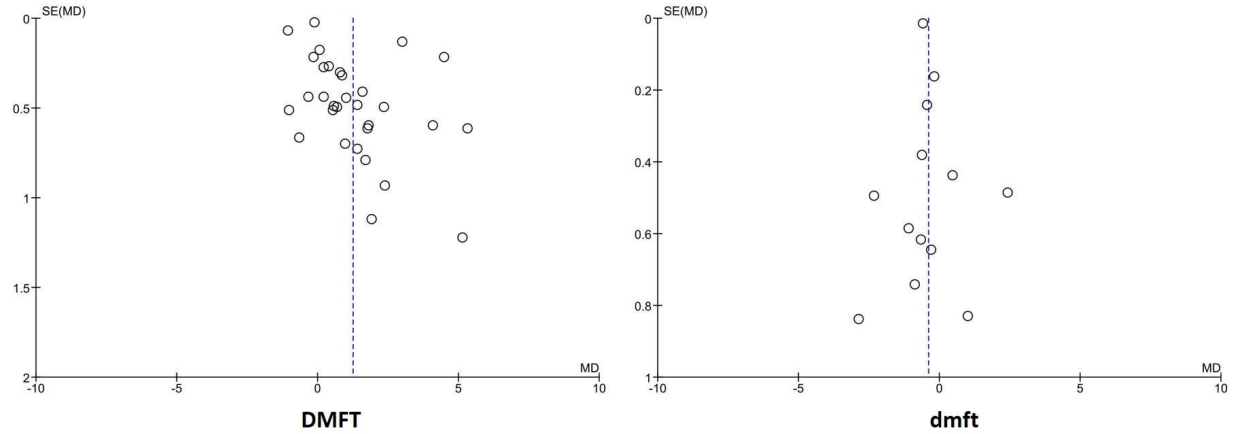


**Fig. 4** Funnel Plot presentations of DMFT and dmft indexes

| Outcomes | Anticipated absolute effects* (95% CI) | | Relative effect (95% CI) | № of participants (studies) | Certainty of the evidence (GRADE) | Comments |
|---|---|---|---|---|---|---|
| | Risk with healthy group | Risk with Insulin-dependent diabetics | | | | |
| Dental caries frequency assessed with: DMFT score | The mean dental caries frequency ranged from **0.2 to 9.56** DMFT score | MD **1.24 DMFT score higher** (0.74 higher to 1.74 higher) | - | 4680 (31 observational studies) | ⨁◯◯◯ VERY LOW a,b,c | Insulin-dependent diabetics may increase dental caries in the permanent dentition period but the evidence is very uncertain. |
| Dental caries frequency assessed with: dmft score | The mean dental caries frequency ranged from **0.77 to 7.17** dmft score | MD **0.4 dmft score lower** (0.82 lower to 0.02 lower) | - | 2054 (13 observational studies) | ⨁◯◯◯ VERY LOW a,b | The evidence is very uncertain about the effect of insulin-dependent diabetics on dental caries in the deciduous dentition period |

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the __relative effect__ of the intervention (and its 95% CI).

**CI:** Confidence interval; **MD:** Mean difference; **OR:** Odds ratio

**GRADE Working Group grades of evidence**
**High certainty:** We are very confident that the true effect lies close to that of the estimate of the effect
**Moderate certainty:** We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
**Low certainty:** Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
**Very low certainty:** We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

**Explanations**

a. Most information is from studies at moderate risk of bias
b. Confidence intervals (CIs) show minimal overlap and the I2 which quantifies the proportion of the variation in point estimates due to among-study differences is large.
c. There is suspicion of publication bias according to Egger regression analysis or Funnel Plot

**Fig. 5.** Grade Analysis: Summary of Findings table

the primary dentition was weakened by the sensitivity analysis, and the decline in significance value.

A meta-analysis performed by Wang, et al.[24] found that the prevalence of dental caries was high among children and adolescents with IDDM independent. However, there are some differences between the present study and that of Wang, et al.[24]. In the present meta-analysis, we evaluated the permanent and deciduous dentitions separately to decrease the heterogenity of the meta-analysis. Because there are differences between dentitions in terms of being affected by dental caries. Since index results are evaluated separately in this study, it is not an accurate approach to compare the results of these two studies. Furthermore, the results of another meta-analysis published in 2020 are in line with the findings of the present study.[25]

The flow rate of saliva plays a crucial role in maintaining oral health.[26] A decrease in saliva flow rate can lead to the development of dental caries due to secondary factors such as the proliferation of cariogenic microbial flora. These microorganisms, including Streptococcus mutans and Lactobacillus, create an environment with a low pH that accelerates the progression of dental caries. Researches have shown that individuals with IDDM tend to experience a decrease in salivary flow rate and pH, as well as an increase in Streptococcus mutans counts.[27-29] The formation of dental diseases is more associated with unstimulated saliva than stimulated saliva, which can be produced through chewing and has a shorter duration. A flow rate of 0.1-0.25 ml is considered low for unstimulated saliva, and less than 0.1 is considered very low.[30] A study by Hatipoğlu, et al.[4] revealed that individuals with IDDM have a salivary flow rate that is around 0.2 ml lower than healthy individuals. This decrease in flow rate can cause xerostomia, which can lead to the formation of dental caries and periodontal disease. It is crucial to maintain a healthy flow rate of saliva to prevent the onset and progression of dental diseases.

It is of utmost importance to acknowledge that the present study had certain limitations. While dental caries is a multifactorial condition that is impacted by various lifestyle choices, such as sugar intake, dental hygiene, dietary habits, level of education, and age, it is plausible that the results may have been influenced by these factors, which were not assessed in the studies included. Furthermore, due to the constraints of the article, factors such as saliva glucose levels, metabolic control, and duration of diabetes could not be evaluated. One of the limitations of the study was that it solely included articles written in English. This could potentially lead to language bias, as important information or perspectives from non-English sources may have been overlooked or excluded entirely. Hence, it is vital to interpret the study results with caution and consider the aforementioned limitations while drawing conclusions.

## 5. Conclusion

After conducting both qualitative and quantitative analyses, it appears that IDDM may have an impact on the occurrence of dental caries in permanent teeth. However, no similar effect was observed for the deciduous dentition. It's worth noting, however, that due to the heterogeneity of the analyses, a high risk of biases, and the use of observational studies, the evidence connecting IDDM to these factors is not yet conclusive and requires further investigation. Additional research is needed to confirm these findings and to better understand the potential impact of IDDM on dental health during the permanent dentition period.

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**Conflict of Interest**

The authors declare that no conflict of interest is available

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Original Article

# Comparative Evaluation of Canal Transportation and Centering Ability of TruNatomy and MicroMega One RECI in Curved Root Canals

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CLINICAL SIGNIFICANCE

This study underscores the need for dentists to consider the unique anatomical and clinical needs of each case when selecting an endodontic file system.

ABSTRACT

**Objectives**: To compare the canal transportation and centering ability of two different file systems, TruNatomy (TRN) and MicroMega One RECI (MMOR), in curved root canals.

**Materials and Methods:** Forty upper premolars with root canal curvatures ranging from 25° to 40° were divided into two groups (n=20): Group A, instrumented with TRN file system in continuous rotation motion, and Group B, instrumented with the MMOR file system in reciprocating motion. Pre- and post-instrumentation CBCT scans were taken using the Kodak Carestream CS 9300 machine to analyze canal transportation and centering ability at different canal levels (2mm, 5mm, 8mm). Data analysis was conducted using a student t-test for comparison between the groups.

**Results:** The study demonstrated that the MMOR system significantly reduced canal transportation at 5mm and 8mm levels in the mesiodistal plane compared to the TRN system ($p<0.05$). In the buccolingual plane, significant differences were noted only at 8mm. For centering ability, MMOR showed superior performance at 5mm and 8mm in the mesiodistal plane ($p<0.05$), whereas TRN was better at 2mm ($p<0.05$). No significant differences were observed in the buccolingual plane at 5mm and 8mm levels. These findings highlight the distinct advantages of each system in specific clinical contexts.

**Conclusion:** While both systems are clinically effective, their selection should be tailored to the specific requirements of each case. The MMOR system may be preferable in scenarios where minimal canal transportation and precise centering are paramount. In contrast, the TRN system is a viable option in cases requiring strong apical centering ability.

## 1. Introduction

Root canal therapy necessitates accurate and efficient shaping of the canal to ensure successful treatment outcomes. Recent advancements in endodontics have led to the development of numerous novel instrumentation systems, each promising enhanced shaping capabilities and procedural safety by minimizing common errors such as ledges, perforations, and excessive thinning of canal walls.[1] The effectiveness of such systems is typically assessed through a variety of metrics derived from micro-computed tomographic scans. These metrics provide insights into how each system impacts the spatial characteristics within the root canal at various levels, thereby influencing the treatment outcomes.[2-4]

Two such contemporary instrumentation systems are the TruNatomy (TRN [Dentsply Sirona, York, PA]) and MicroMega One RECI (MMOR [Micro-Mega, Besançon, France]). Each of these systems boasts unique properties due to their specific geometric designs, metallurgical makeup, and kinematic characteristics.[5,6]

The TRN system is a rotary file system composed of superelastic nickel-titanium (NiTi) wires. The system's innovative heat treatment process reduces memory and enhances its superelastic properties, thus supporting improved canal shaping with minimal risk of procedural errors. TRN's distinguishing features such as its regressive tapers and slim design contribute to its reported superior fatigue resistance in comparison to other systems.[4,7]

On the other hand, the MMOR system is a reciprocating single-file system, featuring a unique metallurgical treatment that enhances the flexibility of the instrument while reducing its memory. MMOR's instrument design includes a progressive taper and an offset mass of rotation, which claim to increase the instrument's efficiency while reducing the risk of canal transportation and file separation. The system's shaping ability, particularly in curved or complex canals, has been subject to several studies, highlighting its effectiveness in maintaining original canal anatomy.[5,8]

The primary aim of this study is to evaluate and compare the canal transportation and centering ability of the TRN and MMOR systems in curved root canals. The null hypotheses tested were that there would be no difference in canal transportation and centering ability in curved root canals amongst these instrumentation systems.

## 2. Materials and Methods

### 2.1. Sample Selection and Preparation

This study was approved by the institutional ethics committee of Oman Dental College (ref no. 2023-AJ-19Y). The selected sample size was 40 human mandibular premolars, each with a single canal and a curvature greater than 25° but less then 40°, as determined by Schneider's method.[9] In this method, x-rays of the teeth were taken in both the buccolingual and mesiodistal planes. On the x-ray, a line was drawn parallel to the canal's long axis. A second line was drawn from the apical foramen to intersect the first at the point where the canal started to leave the tooth's long axis. The acute angle formed was measured with SIDEXIS XG software's "Measure angle" function (Sirona Dental Systems GmbH, Bensheim, Germany).

The teeth were stored in saline, and each tooth was standardized at a length of 15 mm. Following this, the teeth were arranged in a template and scanned using a Kodak Carestream CS 9300 CBCT machine (Carestream Dent LLC, Atlanta, G, USA).

### 2.2. Root Canal Preparation

Subsequently, the teeth were randomly assigned into one of two experimental groups (Group A and Group B), each containing 20 teeth. In Group A, root canal preparation was executed using a TruNatomy file (Dentsply Sirona, Germany) with continuous rotation motion, whereas Group B utilized a MicroMega One RECI file (Micro-Mega SA, Besancon, France) with reciprocating motion. A single operator, previously trained in both methods, performed all the instrumentation.

### 2.3. Assessment of Root Canal Preparation

The parameters for assessing the root canal preparation were based on the formula provided by Gambill et al.[10] The degree of canal transportation was calculated using the formula ($[a_1-a_2]-[b_1-b_2]$), with $a_1$ and $a_2$ representing the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented and instrumented canal, respectively. Similarly, $b_1$ and $b_2$ represent the distance from the distal edge of the root to the distal edge of the uninstrumented canal and instrumented canal, respectively. A result of "0" indicates no canal transportation while any other number indicates that transportation has occurred. The centering ability was calculated using the formula $(a_1-a_2)/(b_1-b_2)$ or $(b_1-b_2)/(a_1-a_2)$, depending on which number was lower, the lower figure was considered as the numerator. A result of "1" indicates perfect centering (Fig. 1). Figure 2 displays superimposed pre- and post-operative CBCT scans, illustrating the changes in canal morphology resulting from the use of the TRN and MMOR systems.

### 2.4. Statistical Analysis

Statistical analysis was conducted using the student t-test for inter-group comparisons at different measurement distances from the apex. This included evaluating canal transportation and centering ability for both the TRN and MMOR systems in buccolingual and mesiodistal planes. The t-test was utilized to identify significant differences in performance between the two systems at the specified distances of 2mm, 5mm, and 8mm from the apex. The threshold for statistical significance was set at 0.05. This analysis method provided a clear comparison of the two endodontic systems' effectiveness in canal shaping and their respective impacts on canal transportation and centering ability. All analyses were performed utilizing R software (4.3.2). The assumption of normality was checked based on the Shapiro-Wilk test ($\alpha$=0.05). The test priori power is strong (0.9178).

## 3. Results

Throughout the study, there were no incidents of instrument separation during the procedures.

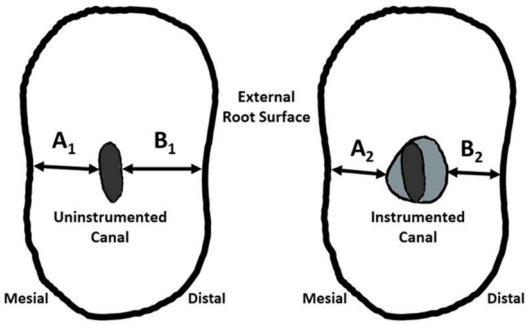


**Fig. 2.** Comparative CBCT imaging of canal morphology: superimposed scans pre- and post-instrumentation, highlighting the impact of two different endodontic rotary systems on canal morphology.

Table 1 showcases the mean values and standard deviations for canal transportation. The table also includes p-values from Student t-tests, comparing the TRN and MMOR systems at different distances from the apex in both buccolingual and mesiodistal planes. In the mesiodistal plane, at distances of 5mm and 8mm from the apex, the MMOR system demonstrated a lesser amount of canal transportation that was significantly different compared to the TRN system ($p < 0.05$). At a depth of 2mm from the apex in the mesiodistal plane, however, no significant differences in canal transportation were observed between the two systems ($p > 0.05$). In the buccolingual plane, a significant difference favoring the MMOR system was noted only at the 8mm level, while at the 2mm and 5mm levels, the differences were not statistically significant ($p > 0.05$).

Table 2 demonstrates the means and standard deviations for centering ability. At the 5mm and 8mm levels in the mesiodistal plane, the MMOR system displayed significantly better centering ability compared to the TRN system ($p < 0.05$). Conversely, at the 2mm level in the same plane, the TRN system showed superior centering ability, with the difference being statistically significant ($p < 0.05$). In the buccolingual plane, a significant difference was observed only at the 2mm level, favoring the TRN system ($p < 0.05$). At the 5mm and 8mm levels in the buccolingual plane, no statistically significant differences were noted ($p > 0.05$).

## 4. Discussion

The MMOR system is considered to be one of the newest systems introduced in the field and has been mentioned only four times in the existing literature. One study investigated the Effect of Different Endodontic Access Cavities on Instrumentation

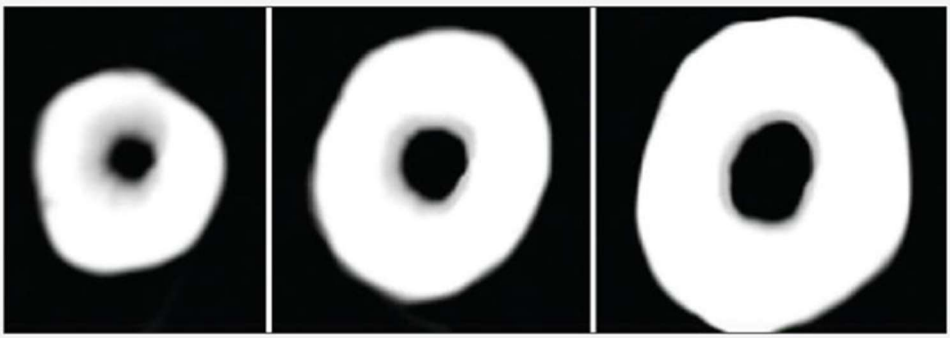

**Fig. 1.** Illustrative representation of tooth sections indicating the derivation of transportation, centering ratios, and remaining dentin thickness measurements. The uninstrumented image (on the left) depicts the original canal space as highlighted by the darker shade. The instrumented image (on the right) showcases the canal's contour post-instrumentation, indicated by the lighter shade.

**Table 1**. Mean and Standard Deviation of Canal Transportation (mm from apex) for TruNatomy and One RECI Systems at 2mm, 5mm, and 8mm distances

| | | TruNatomy | One RECI | p-value |
|---|---|---|---|---|
| Buccolingual | 2mm | 0.054±0.012 | 0.069±0.031 | 0.051 |
| | 5mm | 0.075±0.010 | 0.080±0.008 | 0.089 |
| | 8mm | 0.087±0.009 | 0.067±0.011 | **<0.001** |
| Mesiodistal | 2mm | 0.049±0.008 | 0.053±0.009 | 0.146 |
| | 5mm | 0.136±0.026 | 0.021±0.010 | **<0.001** |
| | 8mm | 0.156±0.011 | 0.037±0.011 | **<0.001** |

**Table 2**. Mean and Standard Deviation of Centering Ability (mm from apex) for TruNatomy and One RECI Systems at 2mm, 5mm, and 8mm distances

| | | TruNatomy | One RECI | p-value |
|---|---|---|---|---|
| Buccolingual | 2mm | 0.644±0.018 | 0.604±0.028 | **<0.001** |
| | 5mm | 0.571±0.010 | 0.568±0.020 | 0.552 |
| | 8mm | 0.542±0.034 | 0.521±0.046 | 0.109 |
| Mesiodistal | 2mm | 0.620±0.027 | 0.586±0.050 | **0.011** |
| | 5mm | 0.379±0.031 | 0.822±0.040 | **<0.001** |
| | 8mm | 0.345±0.047 | 0.728±0.052 | **<0.001** |

Efficacy;[11] another assessed the Cyclic Fatigue Resistance of Reciprocating versus Continuous Rotating Nickel-Titanium Instruments and found that MMOR exhibited suitable mechanical properties with the highest cyclic fatigue resistance and angle of rotation among other instruments tested;[8] a third study measured the Apically Extruded Debris in Curved Root Canals and revealed that the MMOR system produced statistically lower apically extruded debris than other systems;[5] and the fourth was a narrative review that touched on this newly introduced system.[6] These studies underline the burgeoning interest in and early successes of the MMOR system, while also emphasizing the need for further research to fully understand its range of applications and potential advantages. To our knowledge, this work represents the first investigation into the centering ability and canal transportation of the MMOR system, providing essential insights into these critical aspects of this new endodontic file system.

The outcomes of the current study reveal notable differences in canal shaping between the TRN rotary system and the MMOR system. Their impacts on canal transportation and centering ability in this study were distinct, despite both systems being engineered for efficient root canal shaping.

This study highlighted that the MMOR system resulted in less canal transportation at both the coronal and middle levels in the mesiodistal plane, and at the coronal level in the buccolingual plane. It also demonstrated superior centering ability at these levels. Conversely, the TRN system exhibited notably good apical centering ability, particularly at the apical level, showing significant superiority over MMOR. This could be attributed to its unique design features, such as off-center cross-sections and progressive tapering at the apical section.[6] Interestingly, the TRN system showed better performance apically, while the MMOR system excelled in the middle and coronal thirds of the canal. These observations align with previous research that has emphasized the strong performance of the TRN system, especially in the apical third of the canal.[12]

Despite the TRN system's well-documented efficacy in past research,[4,12,13] our current investigation indicates that it was outperformed by the MMOR system in certain respects. This outcome could potentially be attributed to the system's reciprocating motion, which may lead to a lower degree of canal transportation compared to rotary systems. In addition, the variable and asymmetrical section of the MMOR system might enhance cutting efficiency and debris clearance, potentially facilitating better canal centering during the procedure.[6,14]

The findings of this study can be considered clinically relevant. Past research suggests that canal transportation less than 0.3 mm would have a minimal impact on the treatment prognosis.15 All canal transportations in this study were below this threshold, thus underscoring the clinical efficacy of both systems. However, the differences observed between the two systems, particularly at the coronal and middle levels where MMOR demonstrated advantages, and at the apical level where TRN excelled, suggest that the selection of the endodontic file system should be tailored to the specific requirements of each case. Dentists are encouraged to consider these findings when selecting a system, ensuring that their choice aligns with the unique anatomical and clinical needs of each individual treatment scenario.

While our study provides valuable insights into canal transportation and centering ability for the TRN and MMOR rotary systems, it is important to consider certain limitations. Firstly, the use of extracted teeth and simulated clinical settings, though offering a controlled environment for in vitro studies, cannot perfectly replicate the complex and varied morphology of teeth encountered in live patients. In vitro models offer enhanced standardization compared to clinical settings, but they lack the ability to fully mimic the diversity and nuances of dental anatomy found in natural clinical scenarios.

Furthermore, the employment of CBCT in our study, as opposed to Micro-CT, represents another limitation. CBCT, while practical and widely used in dental research, does not provide the high resolution and detailed imaging capabilities of Micro-CT. This difference in imaging resolution could potentially influence the accuracy of our measurements, particularly in assessing fine details related to canal transportation and centering ability. Consequently, these factors should be taken into consideration when interpreting the findings of our study. Future studies, ideally incorporating randomized clinical trials, are required to reinforce and broaden these findings. Additionally, considering parameters such as working time, user-friendliness, and cost-effectiveness will facilitate a more comprehensive evaluation of these systems in real-world clinical settings.

## 5. Conclusion

This study provides an important evaluation of the TRN and MMOR systems, two innovative endodontic file systems. While the TRN system has been well-documented in previous research for its efficiency, particularly in the apical third of the canal, our investigation revealed that the MMOR system, though relatively new and less extensively studied, demonstrates notable advantages in certain aspects of canal shaping.

Our findings indicate that the MMOR system caused less canal transportation and showed superior centering ability at the coronal and middle levels in the mesiodistal plane, and at the coronal level in the buccolingual plane. In contrast, the TRN system exhibited strong apical centering ability, particularly at the apical level.

The clinical relevance of these results is underscored by the fact that all measured canal transportations were below the threshold that might impact treatment prognosis, emphasizing the clinical efficacy of both systems. However, the distinct differences between the two systems, especially in the middle and coronal thirds favoring MMOR, and at the apical level favoring TRN, highlight the importance of system selection based on the specific requirements of each case.

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Original Article

# Assessment of the Root Canal Configuration of Mandibular Anterior Teeth in Turkish Population; A Systematic Review and Meta-analysis

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CLINICAL SIGNIFICANCE

There is a common misconception among dentists that mandibular anterior teeth have a single root and canal. However, this meta-analysis indicates that nearly one-third of mandibular incisors and one-tenth of mandibular canines have a complex canal

ABSTRACT

**Objectives**: This study aims to combine the findings of various research works that leveraged cone-beam computed tomography to investigate the root morphologies of mandibular anterior teeth (MDA) in the Turkish populace.

**Materials and Methods:** The researchers adhered to the PRISMA guidelines while conducting this meta-analysis. Information was extracted from each study, including publication details, sample characteristics, tooth-related factors, methodological factors, and quantitative/qualitative results. The Joanna Briggs guidelines scoring system was employed to determine the risk of bias. The prevalence and Odds Ratio (OR) were analyzed using RevMan 5.3, and forest plots were generated.

**Results:** 10 studies met the eligibility criteria and were included in the analysis. The overall prevalence of Vertucci I in mandibular central (MDS) and lateral (MDL) was 66%, and for Mandibular canines (MDC), it was 88%. The prevalence of Vertucci III in MDS, MDL, and MDC were 20%, 19%, and 6%. The prevalence of teeth with type II, type IV, and type V Vertucci classifications was found to be less than 9% for MDA. Vertucci I prevalences did not exhibit a significant difference between genders (OR=1.31, 95%CI:0.94, 1.82; p=0.11) or between left and right arches (OR=0.96, 95%CI: 0.84,1.10; p=0.59).

**Conclusion:** The common notion that MDAs have a single root and canal is not entirely accurate. Nearly one-third of mandibular incisors and one-tenth of MDC display a varied canal configuration. These observations highlight the importance of clinicians being mindful of the prevalence of multiple canal configurations.

## 1. Introduction

One of the most important factors that can affect the outcome of endodontic treatments is the level of expertise of the treating dentist in identifying and understanding the root canal morphology.[1] The complexity of the root canal system can vary widely among individuals, and even among teeth in the same individual. Inadequate knowledge of the root canal morphology is one of the primary reasons for the failure of endodontic treatments.[2] This can lead to incomplete removal of infected or inflamed tissue, incomplete cleaning and shaping of the canal, and failure to identify and treat accessory canals that may be present. As a result, patients may experience persistent pain, infection, and inflammation, and may require further treatment or even tooth extraction.

The root canal systems of mandibular central (MDS) and lateral (MDL) incisors have a similar shape, with an oval coronal shape that gradually narrows in the middle root.[3] Although mandibular incisors (MDI) usually have a single root, there may be instances where a dentin bridge divides the root into two canals, leading to variations.[3,4] Mandibular canines (MDC) also have a wider root in the bucco-lingual direction and contain a root canal that conforms to this shape, but they rarely have multiple roots or canals.[3,4] Root canal morphology varies among different ethnic populations due to racial and genetic transmission.[5] It was previously believed that mandibular anterior teeth (MDA) typically had a single root and canal [5,6], but recent studies have shown a high probability of two canals in these teeth.[5-9]

Various methods are used in the literature to examine the root canal morphology, including staining, sectioning, and radiographic examinations on extracted teeth.[10-13] However, most of these methods are invasive and can only be applied to extracted teeth. Although periapical radiographs are routinely used in the clinic to evaluate the root canal anatomy, they provide a two-dimensional image and superpositions that make it difficult to determine variations that may exist in the root canals, such as the presence of a second and lateral canal.[14] On the other hand, cone-beam computed tomography (CBCT) systems provide images with high spatial resolution, less radiation dose, and less time compared to computed tomography.[15] For this reason, CBCT has been frequently used in dentistry in recent years for three-dimensional imaging of teeth and maxillofacial region, particularly in endodontics for detailed examinations of the root canal system.

Several studies have been conducted to investigate the root canal morphology of MDA in the Turkish population. However, studies on the Turkish population have reported inconsistent rates of Vertucci 1 configuration, ranging from 41% [16] to 97% [17], in MDA. These discrepancies necessitate a systematic review of the study results and the application of meta-analytical methods to determine the overall prevalence of these configurations and identify the underlying factors contributing to such heterogeneity. To date, no meta-analysis has been carried out for the Turkish population. Therefore, the primary objective of this study is to synthesize the findings of studies that have employed CBCT to examine the root canal morphologies of MDA in the Turkish population.

## 2. Materials and Methods

### 2.1. Guidance and Eligibility criteria

In the conduct of this meta-analysis, the researchers have ensured adherence to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[18] The inclusion criteria for this study were as follows:

1. The study must have evaluated the prevalence of root canal configuration of any MDA in the Turkish population.
2. CBCT or a more sophisticated imaging method must have been employed for the study.
3. The cross-sectional design of the study was another significant criterion for inclusion.
On the other hand, the exclusion criteria for this meta-analysis were as follows:
1. Studies that evaluated a different population were excluded.
2. Any study that employed an imaging or examination method lower than CBCT was excluded from the study.
3. Short communication, review, case report, or case series studies were also excluded from the systematic review.

### 2.2. Information sources and search strategy

In December of 2023, a researcher (F.P.H) conducted a search of various electronic databases, including PubMed, Web of Science, and Scopus. To carry out this search, a combination of free-text terms such as "root canal anatomy," "root canal morphology," "root canal configuration," "mandibular" were utilized. A detailed queries that were used in the information sources can be found in Table 1. In addition, to ensure comprehensive coverage, other researcher (G.M) carefully reviewed the reference lists of all relevant papers gathered during the search process. This was done in order to identify any additional studies that could be considered relevant to the research question.

### 2.3. Study selection and data collection process

To ensure that our study was comprehensive and accurate, we utilized a reference management software, namely EndNote® X9 Thomson Reuters from Philadelphia, PA, USA. Using this software, we carefully screened and removed any duplicate studies that could skew our results. The final selection of candidate studies was then agreed upon by our team of researchers, which included individuals with extensive experience in the field.

We extracted the following information from each study to ensure that we gathered all the necessary information: (1) publication details, including the journal, title, authors, date, country, and city where the study was conducted, (2) sample characteristics, such as sample size, age, and gender of the participants, (3) tooth-related factors, including the examined tooth group, (4) methodological factors, such as the CBCT brand used, voxel size, and root canal classification, and (5) qualitative and quantitative results.

### 2.4. Risk of bias within studies

In order to evaluate the risk of bias in individual studies, two analysts (F.P.H, G.M.) utilized the Joanna Briggs Institute (JBI) critical appraisal tool for prevalence studies.[19] The assessment was conducted independently by each analyst and a mutual agreement was then reached. The Joanna Briggs guidelines scoring system and cutoff points were employed to determine the risk of bias. Studies which scored below 49% were classified as having a "high risk of bias," while those scoring between 50 to 69% were regarded as having a "moderate risk of bias." Studies scoring over 70% were considered to have a "low risk of bias."adhered to for scoring and established cutoff points to classify studies into different risk of bias categories. Studies with up to 49% of questions scored as "yes" were deemed to have a high risk of bias, those with scores ranging from 50 to 69% as moderate risk, while those with more than 70% as low risk.

### 2.5. Summary Measures

The primary outcomes in this study were the Vertucci classification prevalences according to tooth type. To compare the genders and left-right arches (Only Vertucci I variables were based), the Odds Ratio (OR) and its respective 95% confidence intervals (95% CI) were utilized as the primary outcome was dichotomous.

**Table 1.** Queries that were used in information sources

| Database | Search strategy |
|---|---|
| PubMed | (((root canal anatomy[Title]) OR (root canal morphology[Title]) OR (root canal configuration[Title])) AND ((mandibular[Title])))) |
| Web of Science | TI=((root canal anatomy OR root canal morphology OR root canal configuration) AND (mandibular)) |
| Scopus | TITLE(root canal anatomy) OR TITLE(root canal morphology) OR TITLE(root canal configuration) AND TITLE(mandibular) |

### 2.6. Synthesis of results

The standard error of prevalence was determined using the formula $\sqrt{(p(1-p)/n)}$, where p represents the observed prevalence and n denotes the sample size. This calculation was executed via an Excel sheet.[20] To estimate the association between left-right teeth and gender, we employed OR and a 95% CI. The overall prevalence and OR were evaluated using the meta-analysis software, RevMan 5.3 (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark), and forest plots were generated. We determined the statistical heterogeneity among studies using the Higgins $I^2$ test and categorized it as not significant (<30%), moderate (30%–50%), substantial (50%–75%), or considerable (75%–100%).[21] As we could not achieve methodological, clinical, and statistical homogeneity together, we preferred a random-effects model with 95% CI as the meta-analysis model. We set the level of significance at $p < 0.05$.

### 2.7. Risk of Bias Across Studies

In order to assess whether there is a publication bias in the data, the researchers examined the funnel plots visually.

## 3. Results

### 3.1. Study Selection

The current study involved a systematic search of various academic databases, including Pubmed, Web of Science, Scopus, as well as reference lists of relevant papers. The search strategy yielded a total of 707 records, which were subsequently screened for duplicates, resulting in a final pool of 376 studies. Upon further scrutiny, only 10 studies [16,17,22-29] were found to meet the eligibility criteria and were thus included in both qualitative and quantitative syntheses. A graphical representation of the included studies is provided in Supplemental File 1.

### 3.2. Characteristics of the included studies

The present meta-analysis included a series of journal articles, with the earliest one dating back to 2014 [22] and the latest to 2023 [29]. Izmir city [22-24] emerged as the most commonly studied area, with a total of three research articles, whereas the city of Van [28] was investigated in only one study. It is worth noting that, although the Vertucci classification was employed across all studies, three of them [17,23,24] opted for alternative classification systems, namely Ng's and Sert Bayırlı's classifications. Table 2 contains the characteristics of the studies that were included.

### 3.3. Risk of bias within the studies

Upon conducting the analysis of ten studies, it was found that half of the studies displayed a low risk of bias [22,24,25,27,28], while the remaining half exhibited a moderate level of bias [16,17,23,26,29] (Table 3).

### 3.4. Synthesis of results

In the MDA teeth, the prevalence of Vertucci I, II, III, IV, and V

Fatma Pertek Hatipoğlu, Güldane Mağat. J Endod Rest Dent. Volume: 2 Issue: 1 Page: 12-18

**Table 2.** Characteristics of the studies included in the qualitative synthesis (n=10)

| Study | Publication type | Year | City | Age range | Examined Tooth Group | Sample Size | Imaging technique | Classification |
|---|---|---|---|---|---|---|---|---|
| Altunsoy, et al. [22] | Journal article | 2014 | İzmir | 14-70 years | Mandibular/Maxillar central, lateral, canin | MDS: 1582<br>MDL: 1603<br>MDC: 1604 | I-CAT Vision TM Imaging Science<br>Voxel size: 0.3 mm | Vertucci's classification |
| Arslan, et al. [23] | Journal article | 2015 | İzmir | 10-70 years | Mandibular central, lateral | MDS:96<br>MDL:100 | NewTom 5G CBCT machine<br>(QR Srl, Verona, Italy)<br>Voxel size: 0.15 mm | Vertucci's classification,<br>Ng's classification |
| Orhan, et al. [16] | Journal article | 2018 | Ankara | 18-86 years | Mandibular central, lateral, canin | MDS: 261<br>MDL: 275<br>MDC: 266 | 3D Accuitomo<br>180 (Morita, Japan)<br>Voxel size: 0.08-0.25 mm | Vertucci's classification |
| Karataslioglu, et al. [24] | Journal article | 2019 | İzmir | 15-60 years | Mandibular/Maxillar canin | MDC: 419 | NewTom 5G CBCT machine<br>(QR Srl, Verona, Italy)<br>Voxel size: 0.15 mm | Vertucci's classification,<br>Sert Bayırlı's classification,<br>Ng's classification |
| Mağat [25] | Journal article | 2019 | Konya | 14-75 years | Mandibular/Maxillar canin | MDC: 820 | 3D Accuitomo<br>180 (Morita, Japan)<br>Voxel size: - | Vertucci's classification |
| Özsoy, et al. [26] | Journal article | 2019 | Konya | 15-52 years | Mandibular central, lateral | MDS: 118<br>MDL: 119 | * Kavo (Examvision, Dental Excellence Version 1.8.1.10, Biberach, Germany),<br>* Planmeca (Promax 3Bs / 3B, Helsinki, Finland),<br>* Instrumentarıum (Ortopantomograph OP300, Tuusula, Finland),<br>* Kodak (9000/3D sistemi Carestream Health Inc, Rochester NY, U.S.A)<br>* Morita (3D Accuitoma 170, Morita, Tokyo, Japan) | Vertucci's classification |
| Erkan, et al. [27] | Journal article | 2020 | Istanbul | 13-79 years | Mandibular central, lateral, canin | MDS: 939<br>MDL: 947<br>MDC: 937 | ani-CAT17–19 Imaging<br>System (Imaging Sciences Int., Inc.)<br>Voxel size: 0.25 mm | Vertucci's classification |
| Gündüz, et al. [28] | Journal article | 2021 | Van | - | Mandibular/Maxillar canin | MDC: 1002 | Orthophos XG Plus<br>(Sirona, Bensheim, Germany)<br>Voxel size: 0.75 mm | Vertucci's classification |
| Eren, et al. [17] | Journal article | 2022 | Ankara | 18-** years | Mandibular/Maxillar central, lateral, canin, premolar, molar | MDS: 400<br>MDL: 400<br>MDC: 399 | Planmeca (Promax 3Bs / 3B, Helsinki, Finland)<br>Voxel size: 0.20 mm | Vertucci's classification,<br>Sert Bayırlı's classification |
| Okumus, et al. [29] | Journal article | 2023 | Istanbul | 14-76 years | Mandibular/Maxillar canin | MDC: 235 | NewTom VGi evo (CeflaGroup, Verona, Italy)<br>Voxel size: 0.30 mm | Vertucci's classification |

MDS: Mandibular central incisor, MDL: Mandibular lateral incisors, MDC: Mandibular canines

**Table 3.** Risk of bias summary, assessed by Joanna Briggs Institute Critical Appraisal Checklist for prevalence studies (n=10): author's judgments for each included study

| Author | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Total | Risk of Bias |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Altunsoy, et al. [22] | Y | NA | Y | Y | Y | NA | Y | Y | NA | 100% | Low |
| Arslan, et al. [23] | Y | NA | N | Y | N | NA | N | Y | NA | 50% | Moderate |
| Orhan, et al. [16] | Y | NA | N | Y | N | NA | N | Y | NA | 50% | Moderate |
| Karatasliogl u, et al. [24] | Y | NA | Y | Y | N | NA | Y | Y | NA | 83% | Low |
| Mağat [25] | Y | NA | Y | Y | Y | NA | Y | Y | NA | 100% | Low |
| Özsoy, et al. [26] | Y | NA | N | Y | N | NA | Y | N | NA | 50% | Moderate |
| Erkan, et al. [27] | Y | NA | Y | Y | Y | NA | N | Y | NA | 83% | Low |
| Gündüz, et al. [28] | Y | NA | Y | N | Y | NA | Y | Y | NA | 83% | Low |
| Eren, et al. [17] | Y | NA | Y | N | N | NA | Y | Y | NA | 67% | Moderate |
| Okumus, et al. [29] | Y | NA | N | Y | N | NA | U | Y | NA | 50% | Moderate |

Legend: Y= Yes; N= No; U= Unclear, NA= Not applicable; Prevalence Study Checklist: Q1- Was the sample frame appropriate to address the target population? Q2- Were study participants sampled in an appropriate way? Q3- Was the sample size adequate? Q4- Were the study subjects and the setting described in detail? Q5- Was the data analysis conducted with sufficient coverage of the identified sample? Q6- Were valid methods used for the identification of the condition? Q7- Was the condition measured in a standard, reliable way for all participants? Q8- Was there appropriate statistical analysis? Q9- Was the response rate adequate, and if not, was the low response rate managed appropriately? Total= ΣY/Applicable Items. Risk of bias was categorized as high when the study reaches up to 49% score "yes", moderate when the study reached 50% to 69% score "yes", and low when the study reached more than 70% score "yes.

ranges from 41% to 97%, 0% to 36%, 1% to 42%, 0% to 5%, and 0% to 24%, respectively. Overall prevalences of Vertucci I, II, III, IV, and V were 74% (95% CI, 68%–81%), 6% (95% CI, 5%–8%), 13% (95% CI, 11%–16%), 1% (95% CI, 0%–1%), and 4% (95% CI, 1%–7%), respectively. Considerable heterogeneity ($I^2$>75%) was observed in all meta-analyses regarding Vertucci classification. There were significant differences between subgroups in Vertucci I and III (p<0.05), but no significant difference was found in other Vertucci classifications (p>0.05) (Fig. 1-2, Supplemental File 2).

In the subgroup analysis of MDS, the prevalence of Vertucci I, II, III, IV, and V ranges from 43% to 84%, 0% to 28%, 1% to 42%, 1% to 4%, and 0% to 10%, respectively. Overall prevalences of Vertucci I, II, III, IV, and V were 66% (95% CI, 50%–82%), 7% (95% CI, 4%–11%), 20% (95% CI, 9%–31%), 2% (95% CI, 0%–3%), and 3% (95% CI, 0%–6%), respectively. In all meta-analyses, considerable heterogenity ($I^2$>75%) was observed (Fig. 1-2, Supplemental File 2). heterogenity ($I^2$>75%) was observed (Fig. 1-2, Supplemental File 2).

In the subgroup analysis of MDL, the prevalence of Vertucci I, II, III, IV, and V ranges from 41% to 80%, 1% to 30%, 1% to 42%, 0% to 5%, and 1% to 12%, respectively. Overall prevalences of Vertucci I, II, III, IV, and V were 66% (95% CI, 54%–77%), 9% (95% CI, 5%–14%), 19% (95% CI, 8%–31%), 2% (95% CI, 0%–3%), and 4% (95% CI, -1%–9%), respectively. In all meta-analyses, considerable heterogenity ($I^2$>75%) was observed (Fig. 1-2, Supplemental File 2).

In the subgroup analysis of MDC, the prevalence of Vertucci I, II, III, IV, and V ranges from 48% to 97%, 0% to 36%, 1% to 13%, 1% to 2%, and 1% to 24%, respectively. Overall prevalences of Vertucci I, II, III, IV, and V were 88% (95% CI, 84%–92%), 4% (95% CI, 2%–7%), 6% (95% CI, 4%–8%), 1% (95% CI, 0%–1%), and 5% (95% CI, -1%–12%), respectively. In all meta-analyses, considerable heterogenity ($I^2$>75%) was observed (Fig. 1-2, Supplemental File 2).

Vertucci I prevalences did not exhibit a significant difference between genders (OR=1.31, 95% CI: 0.94, 1.82; p=0.11). In all subgroups, no significant difference was found, too (p>0.05). Considerable heterogenity ($I^2$>75%) was observed in the overall effect and all subgroups (Fig. 3).

Vertucci I prevalences did not exhibit a significant difference between left and right arches (OR=0.96, 95% CI: 0.84, 1.10; p=0.59). In all subgroups, no significant difference was found, too (p>0.05). No significant heterogenity (I2<30%) was observed in the overall effect and all subgroups (Fig. 3).

### 3.5. Risk of bias across studies

Following a visual evaluation of the funnel plot analysis, it was determined that there was no observable publication bias. The results of the analysis suggest that the data is unbiased and can be considered reliable (Supplemental File 3).

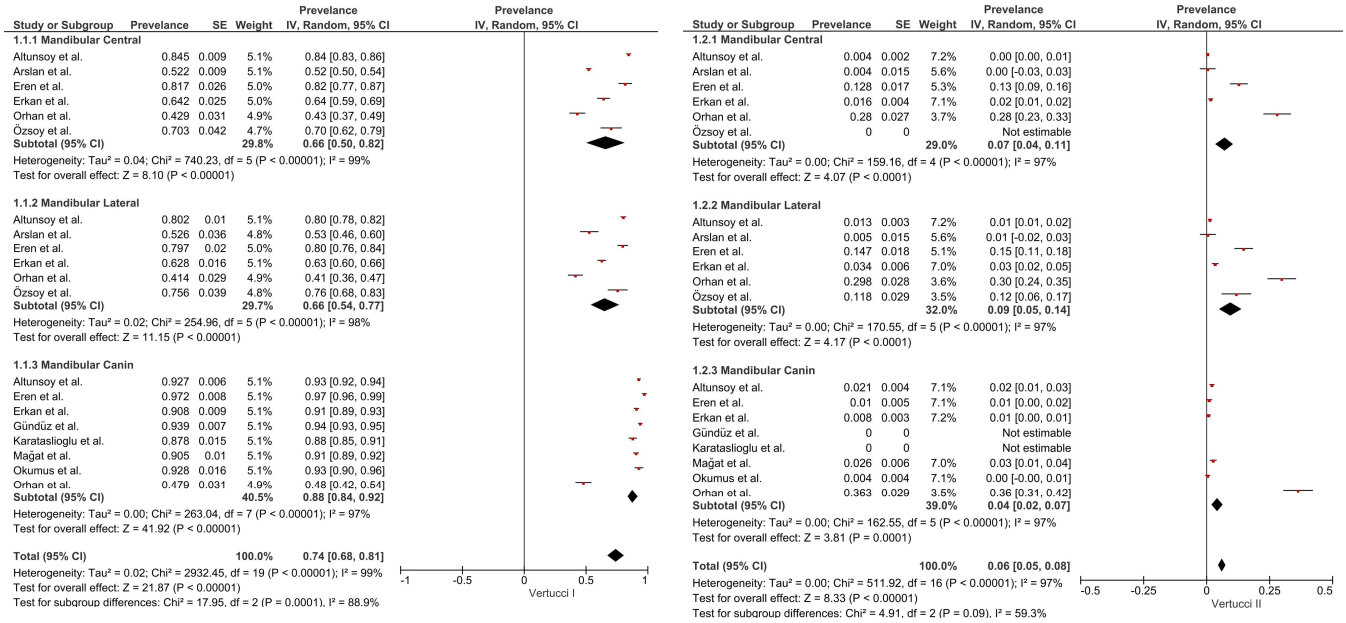


**Fig. 1.** Forest Plot presentation of the prevalence of Vertucci I (left) and II (right) in mandibular anterior teeth

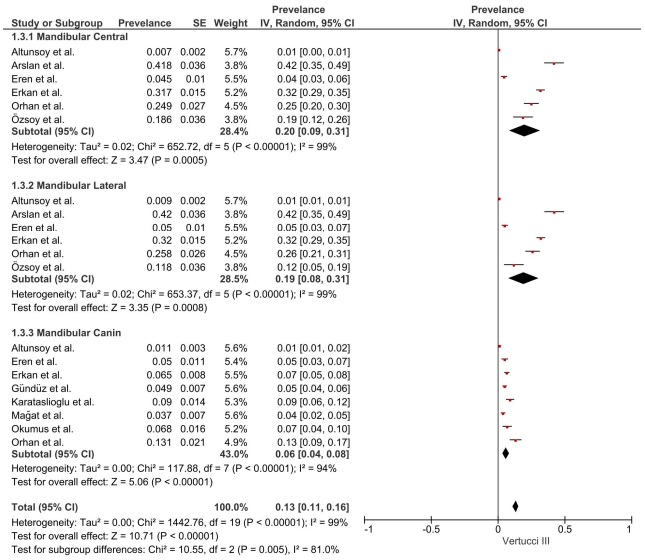


**Fig. 2.** Forest Plot presentation of the prevalence of Vertucci III in mandibular anterior teeth

## 4. Discussion

Achieving a successful endodontic treatment in clinical practice requires thorough cleaning, shaping, and filling of the entire root canal system. Failure to notice and complete treatment of an additional canal can result in treatment failure.[2] Although the majority of MDA have a single root and canal [8,30-33], clinicians should pay attention to the localization of all canals to ensure complete removal of pulp tissue and necrotic debris.[31] Any missed canal can have a direct impact on the treatment's prognosis.[32] Cross-sectional studies of root canal morphology using CBCT can be useful for certain populations with large numbers of patients.[34,35] Many studies have demonstrated the high reliability of CBCT in detecting root and root canal morphology compared to visual inspection by sectioning.[36,37] As a result of these factors, the current study included research that utilized CBCT or other advanced imaging techniques.

The prevalence of Vertucci I in MDA teeth was analyzed in several studies. The study conducted by Orhan, et al. [16] had the lowest prevalence of Vertucci I (43%, 41%, and 48% for MDS, MDL, and MDC, respectively), while the study by Altunsoy, et al. [22] had the highest prevalence of Vertucci I in MDI teeth (84% and 80% for MDS and MDL, respectively). The prevalence of Vertucci I in MDC was found to be 97% in the study conducted by Eren, et al. [17]. In this meta-analysis, the overall prevalence of Vertucci I in MDI was 66%, while that of canine teeth was 88%. The study by Usha, et al. [38], which evaluated the root canal morphology of MDA teeth in the Asian population by meta-analysis, found the prevalence of Vertucci I to be 78.4%, 69.2%, and 91.1% in MDS, MDL, and MDC, respectively.

The prevalence of Vertucci III in MDA teeth was found to be lowest in the study of Altunsoy, et al. [22] (MDA 0.01%), while the highest prevalence of Vertucci III in MDI teeth was observed in the study of Arslan, et al. [23] (MDI 42%), and in MDC teeth, it was found in the study of Orhan, et al. [16] (MDC 13%). This meta-analysis revealed that the total Vertucci III prevalence of MDA teeth was 20%, 19% and 0.06% for MDS, MDL and MDC, respectively. This outcome was consistent with several previous studies showing that the second most common root canal configuration type for MDA is Type III Vertucci.[31-33,39] In contrast to other studies, Orhan, et al. [16] found that the most common type after Type I Vertucci was type II Vertucci. Type II was the third most common type of canal morphology for Vertucci MDI teeth and the fourth most common type for MDC teeth, based on the total prevalence in this meta-analysis. Furthermore, this study found that the proportion of teeth with Type II, Type IV and Type V Vertucci morphology was less than 9% for MDA teeth.

This meta-analysis study consisted of ten studies [16,17,22-29] that examined the root canal morphology of MDA teeth in the Turkish population using CBCT. The varying results between these studies can be attributed to several factors, including disparities in sample sizes, technical differences in the CBCT devices employed (voxel size, fov, irradiation time, etc.), variances in the Turkish subpopulation, and differences in the observers who evaluated CBCT.

Several studies were conducted to determine whether there is a relationship between gender and the Vertucci root canal system type in MDA. Altunsoy, et al. [22] found a higher rate of Type I Vertucci in females for MDS and MDL, while Erkan, et al. [27] found a higher rate in males for MDL. As for canine teeth, numerous studies [16,24,27,28] found a higher rate of Type I Vertucci in males. However, when considering the total effect sizes in this study, no significant relationship was found between genders in any anterior tooth group.

In the research conducted by Lin, et al. [40], it was found that 92.7% of MDS and 89.2% of MDL showed symmetrical morphology on both the right and left sides in terms of the Vertucci's canal configuration. Similarly, in the study by Taha, et al. [6], the rate of bilateral symmetry between the right and left sides was found to be 75.42%, 67.48%, and 64.84% for MDS, MDL, and MDC, respectively. However, it should be noted that this meta-analysis

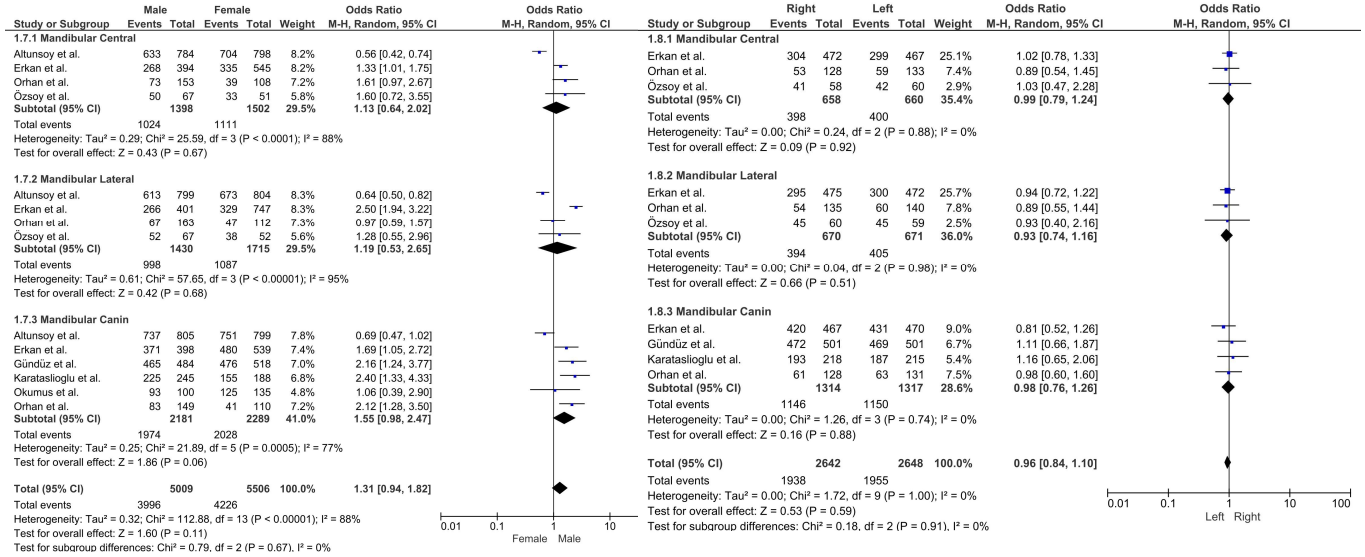


**Fig. 3.** Forest Plot presentation of the comparison between genders (left) and arches (right) regarding the prevalence of Vertucci I in mandibular anterior teeth

did not specify the root canal variation between the right and left teeth of the same patient, which prevented the evaluation of bilateral symmetry ratios. Nevertheless, the study found no significant difference in the Type I Vertucci ratio between the right and left MDA, indicating that the presence of a single canal in one tooth of a patient makes it likely that the symmetry tooth will also have a single canal.

It is quite common for dentists to hold the belief that MDA have only a single root and canal. However, this misconception can sometimes lead to incomplete removal of infected or inflamed tissue, as well as incomplete cleaning and shaping of the canal.[1] In addition, the failure to identify and treat accessory canals that may be present can further exacerbate the problem. This can result in patients experiencing persistent pain, infection, and inflammation, and may ultimately require more extensive treatment or even the extraction of the tooth.[2] To address this issue, this meta-analysis has revealed that nearly one-third of MDI and one-tenth of MDC exhibit a complex canal configuration in the Turkish population. Therefore, it is important for dentists to update their knowledge and understanding of the canal configurations in mandibular anterior teeth to ensure that they are providing their patients with the most effective and appropriate treatment options available.

This study has some limitations that need to be considered. The low sample size of some studies may lead to a risk of bias since rare configurations may not be detected. The reliability of the data acquired is subject to significant fluctuations based on the proficiency of the observer, leading to potential observer bias. Although some studies used multiple observers, inter-rater reliability was not determined. Heterogeneity may also arise from differences in CBCT device, voxel size, and FOV area since changing voxel sizes can increase or decrease the error in detection. Furthermore, the studies were conducted mostly in the same cities, which limits the generalizability of the results to the entire Turkish population. Publication bias was not a concern based on the funnel plot analysis; already, most of the studies were published in relatively lower-quality journals. However, the methodological quality of some studies is questionable since they do not mention the percentage of cases that cannot be classified using Vertucci.

## 5. Conclusion

Within the limitation of the study, the total prevalence of Vertucci I configuration in the Turkish population was found for MDI and MDC teeth at 66% and 88%, respectively. Vertucci III is the second most common root canal configuration type for MDA. No discernible variations were found between the genders or the right and left arches for Vertucci I. Contrary to the belief that MDAs generally have a single root and canal, the data reveals that almost one-third of MDI teeth, and one-tenth of MDC teeth have a complex canal configuration. These findings suggest that clinicians should be aware of the prevalence of multiple canal configurations and be cautious during root canal treatments to avoid potential complications.

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**Conflict of Interest**

The authors declare that no conflict of interest is available

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Case Report

# Autotransplantation of a mature wisdom tooth to a recipient site with a large endodontic lesion: a case report

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CLINICAL SIGNIFICANCE

Successful autotransplantation of a vital wisdom tooth using minimally invasive techniques and CEM cement for root-end filling demonstrates the procedure's feasibility, emphasizing optimal endodontic management for long-term success in replacing non-restorable teeth.

ABSTRACT

Tooth autotransplantation is a valuable treatment option for various dental conditions, offering the potential to preserve natural dentition and restore oral function. This case report describes the successful autotransplantation of a vital wisdom tooth (tooth 38) in a 34-year-old woman to a recipient site (tooth 37) with a non-restorable endodontically treated tooth and a large endodontic lesion. The procedure involved atraumatic extraction of tooth 37, extraoral root-end preparation and filling of tooth 38 with calcium-enriched mixture (CEM) cement, and immediate repositioning of tooth 38 into the extraction socket of tooth 37. Postoperative follow-up demonstrated successful healing, integration, and functional adaptation of the transplanted tooth. This case report highlights the clinical feasibility and favorable outcomes of autotransplantation using minimally invasive techniques and emphasizes the importance of proper endodontic management in ensuring long-term success.

## 1. Introduction

Tooth autotransplantation is a technique that involves the extraction and repositioning of a donor tooth from one site to another recipient socket within the same individual.[1] Over the years, various techniques have been employed to enhance the success rate of this procedure and optimize the outcomes for both the donor and recipient sites.[2] Advancements in technology, including the use of cone-beam computed tomography (CBCT), have contributed to the development of innovative approaches in autotransplantation; it aids in comprehensive assessments for better treatment planning, particularly in the evaluation of root morphology, bone structures, and pathological conditions. In addition, computer-aided rapid prototyping or tooth replica, enabling accurate positional planning and improving surgical ease.[3, 4] Autotransplantation offers the advantage of preserving natural dentition and restoring oral function, making it an attractive treatment option in dentistry.

Studies have reported varying success rates for autotransplantation procedures, with factors such as patient age, donor tooth type, and surgical technique influencing the outcomes.[5] Generally, the success rates range from 75% to 95% for teeth transplanted to the permanent dentition and are even higher for premolars and incisors compared to molars.[2, 5] The prognosis of autotransplanted teeth can also be influenced by factors such as root development stage, periodontal ligament integrity, and the presence of associated pathologies.[5]

One crucial aspect in the success of autotransplantation is the endodontic treatment for the transplanted tooth. The meticulous management of the pulp and root canal system is vital to ensure the long-term survival and function of the transplanted tooth. This typically involves root canal treatment (RCT) of the tooth prior to transplantation, ensuring that the pulp is properly cleaned, shaped, and filled with an appropriate endodontic material.[6]

Additionally, the use of novel biomaterials, such as calcium-enriched mixture (CEM) cement, for root-end filling during endodontic surgeries has gained attention.[7] CEM cement exhibits excellent biocompatibility, sealing ability, bioactivity, and cementogenesis which can contribute to successful periradicular healing.[8] Studies have reported favorable outcomes with the use of CEM cement in surgical endodontics [9], highlighting its potential as an effective endodontic biomaterial for transplanted teeth.

Autotransplantation offers the advantage of preserving natural dentition and restoring oral function, making it an attractive treatment option in dentistry. This case report aims to describe the successful autotransplantation of a vital wisdom tooth using minimally invasive techniques, emphasizing the role of CBCT-assisted assessments, and underscoring the importance of proper endodontic management for achieving favorable long-term outcomes.

## 2. Detailed Case Description

A 34-year-old woman presented with a non-restorable failed endodontically treated tooth 37, which caused discomfort and pain. Upon clinical examination, it was evident that tooth 37 had recurrent caries beneath a non-suitable porcelain-fused-to-metal (PFM) crown, periodontal probe >3mm, and an adjacent fully erupted/healthy wisdom tooth. Due to the patient's severe gag reflex during intraoral radiography, an orthopantomogram (OPG) image was obtained instead (Fig. 1A), revealing additional findings such as a non-fitted PFM crown, multiple recurrent caries, poor endodontic treatment, and a large endodontic lesion (Fig. 1B-D). Cone-beam computed tomography (CBCT) scans further

confirmed extensive bone destruction around the tooth 37 and perforated buccal cortical bone (Fig. 1B-D).

To determine the most appropriate treatment approach, a comprehensive evaluation was conducted, consisting of a thorough clinical examination, CBCT assessments, and a review of the patient's dental and medical history. The assessment revealed that tooth 38 exhibited similar root morphology to tooth 37 and maintained a healthy periodontal condition. In contrast, tooth 37, the recipient site, displayed a large apical lesion of endodontic origin as observed on the CBCT scans. Consequently, tooth 37 was determined to be non-restorable.

Based on these findings, tooth autotransplantation emerged as a viable and advantageous treatment option for the patient. The patient expressed a strong desire to preserve her natural dentition and avoid tooth loss whenever possible. Additionally, the patient's normal medical history further supported the suitability of autotransplantation as the chosen treatment approach.

After obtaining informed consent and administering local anesthesia, tooth 37 was extracted using gentle elevation and luxation techniques. Subsequently, tooth 38 was atraumatically extracted, and extraoral root-end preparation and root-end filling were performed using CEM cement (BioniqueDent, Tehran, Iran). The decision to opt for retrograde root-end filling instead of traditional orthograde root canal treatment was deliberate and guided by the aim to achieve a three-dimensional seal at the exit of root canals without unnecessary destruction of tooth structure. Without any curettage, the extraction socket of tooth 37 was meticulously cleaned using copious irrigation with sterile normal saline in preparation for receiving tooth 38. With careful attention to alignment and occlusal harmony, tooth 38 was directly repositioned in the extraction socket of tooth 37. The tooth was gently guided into its new position to ensure proper integration and stability (Fig. 1E). The patient received detailed postoperative instructions, including guidance on proper oral hygiene measures and adherence to a soft diet during the initial healing period. Regular follow-up appointments were scheduled to monitor the progress of the healing process and ensure optimal outcomes.

During the 1-month follow-up examinations, the patient reported no discomfort or functional issues associated with the transplanted tooth. Clinical and radiographic assessments showed successful healing of the endodontic lesion and proper integration of tooth 38 at the 1-year follow-up (Fig. 1F). At the 5-year follow-up, the transplanted tooth exhibited a normal periodontal ligament width and demonstrated functional adaptation within the occlusal scheme (Fig. 1G). These positive outcomes indicate the success of the autotransplantation procedure and the favorable integration of the transplanted tooth into the patient's oral environment.

## 3. Discussion

Tooth autotransplantation is a complex procedure that involves

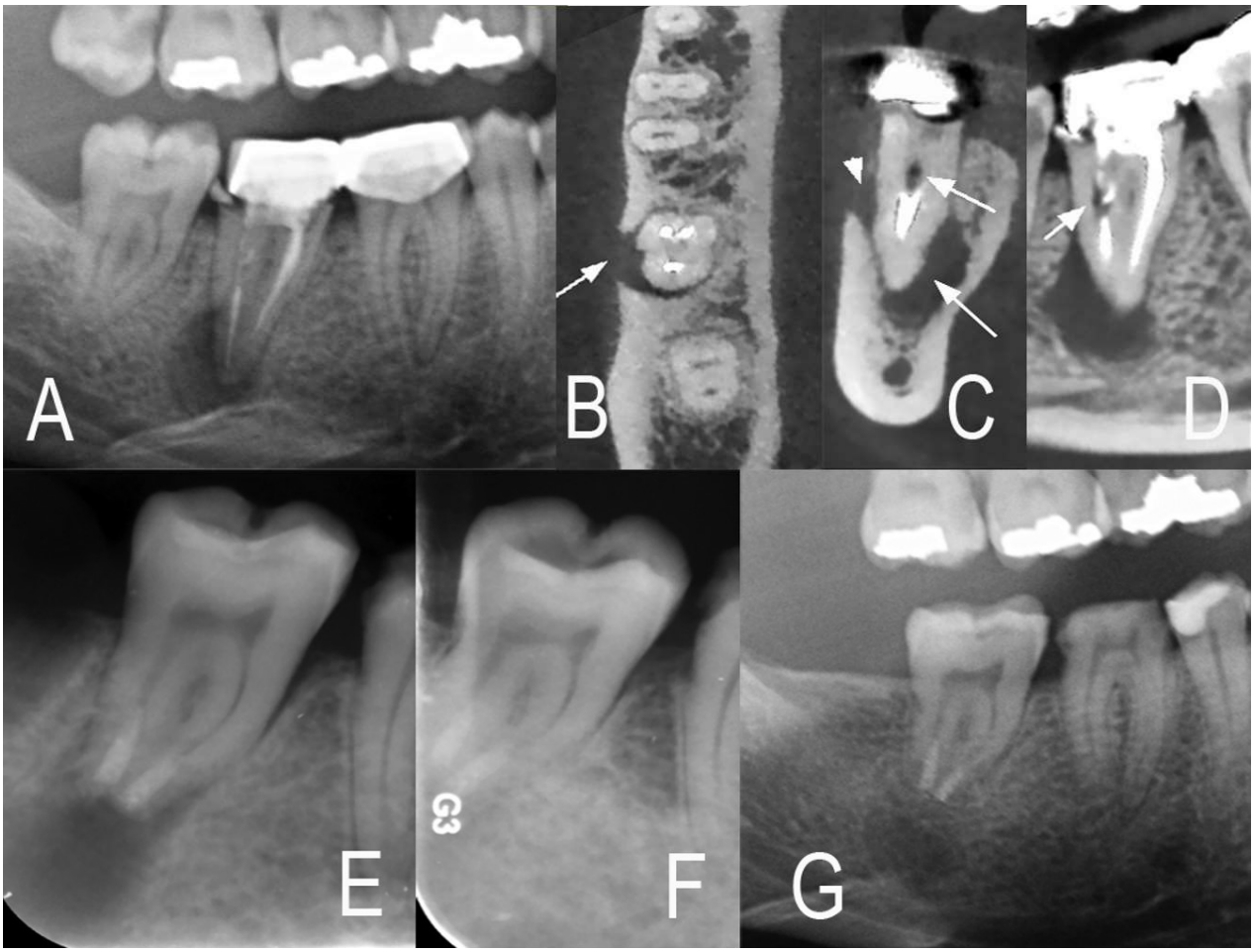


**Fig. 1.** Radiographic Presentation of Autotransplantation Procedure (A) Orthopantomogram (OPG) image showing tooth 37 with a defective PFM crown, recurrent caries, poor root canal obturation, and a large endodontic lesion. (B-D) Cone-beam computed tomography (CBCT) scans, in axial/coronal/sagittal planes, demonstrating extensive bone destruction around tooth 37 and perforated buccal cortical bone. (E) Immediate postoperative radiograph confirming the successful tooth autotransplantation procedure. (F) Radiographic assessment at the 1-year recall, demonstrating successful healing of the endodontic lesion and proper integration of tooth 38. (G) Radiographic assessment at the 5-year recall, showing a normal periodontal ligament width and functional adaptation of the transplanted tooth within the occlusal scheme.

the extraction and repositioning of a tooth from one site to another within the same individual. In this case report, autotransplantation was successfully performed in a 34-year-old woman with a non-restorable failed endodontically treated tooth 37, utilizing a minimally invasive approach. The patient's preference to preserve her natural dentition and avoid tooth extraction made autotransplantation an appealing treatment option. Autotransplantation offers several advantages compared to tooth extraction and the need for replacement.[10] By preserving the natural dentition, autotransplantation helps maintain occlusal harmony and eliminates the requirement for invasive procedures and their associated complications. In this specific case, autotransplantation also provided the potential for periodontal regeneration, further enhancing the long-term stability and success of the treatment.[11] Furthermore, the success of autotransplantation depends on the meticulous surgical techniques employed and the proper management of the transplanted tooth. In this case, a minimally invasive approach was utilized, ensuring atraumatic extraction of tooth 37 and preservation of the periodontal ligament during the extraction of tooth 38. Additionally, the extraction of tooth 37 helped to eliminate the etiologic factors associated with the large endodontic lesion, contributing to its healing.

The decision to proceed with autotransplantation was made after a comprehensive evaluation, encompassing a thorough clinical examination and using CBCT assessments as a helpful tool.[12] It is important to note that computer-aided rapid prototyping or other techniques were not employed in this case. Instead, CBCT imaging alone was used to ensure the adaptability of tooth 38 to the recipient site. The assessment revealed that the recipient site, tooth 37, had a large apical lesion that was visible on CBCT scans, indicating a suitable size for placement of tooth 38. The donor tooth, tooth 38, also exhibited favorable/similar root morphology and a healthy periodontal condition. These findings supported the suitability of autotransplantation as the preferred treatment option for this case.

In cases where the orthograde approach is taken, accessing the crown, preparing the entire root canals, and obturating the canal path until the root apex is a standard procedure to ensure comprehensive sealing. However, when accessing the root apex via surgery, the need for traditional root canal treatment that involves the removal of significant tooth structure becomes unnecessary. The retrograde filling in this scenario was chosen to preserve maximum tooth structure, maintaining the natural strength and durability of the transplanted tooth while effectively addressing endodontic pathology. This approach not only aims to achieve the desired therapeutic outcome but also minimizes unnecessary invasive procedures, contributing to the overall success and longevity of the treatment.

The placement of the root-end filling using an endodontic biomaterial plays a critical role in the success of the procedure.[13] When the root-end filling is placed appropriately, it can effectively seal the path of communication between the root canal system and the periradicular tissues. By sealing the root-end, the risk of microbial contamination and subsequent inflammation in the periradicular tissues is minimized. The use of biomaterials such as CEM cement for root-end filling has been shown to provide an effective seal and promote cementogenesis.[8]

Regular follow-up visits and radiographic assessments are essential to monitor the healing process and evaluate the integration and stability of the transplanted tooth. In this case, the patient reported no discomfort or functional issues related to the transplanted tooth at the 1-month follow-up. Clinical and radiographic assessments confirmed successful healing of the extraction site and proper integration of tooth 38 at the 1-year follow-up. The transplanted tooth exhibited normal PDL and showed signs of functional adaptation within the occlusal scheme at the 5-year recall.

## 4. Conclusion

In conclusion, this case report demonstrates the successful autotransplantation of a vital wisdom tooth, after root-end filling with CEM cement, to replace a non-restorable failed endodontically treated tooth. Autotransplantation proves to be a valuable treatment option for preserving natural dentition, achieving occlusal harmony, healing endodontic lesions, and potentially promoting periodontal regeneration. With careful case selection, meticulous surgical techniques, and appropriate endodontic management, autotransplantation can provide favorable outcomes and contribute to the long-term oral health and function of patients.

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Case Report

# Ultraconservative reattachment for managing complete crown fracture in an endodontically treated tooth

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CLINICAL SIGNIFICANCE

This ultraconservative reattachment approach offers a cost-effective and aesthetically pleasing solution for managing complete crown fractures in older patients, preserving tooth structure and function while emphasizing the importance of conservative interventions in dental trauma cases.

ABSTRACT

This case report investigates an ultraconservative approach to managing a complete crown fracture in a 56-year-old patient with a previously endodontically treated tooth (tooth 21; treated ten years ago). The study contributes to the existing literature by illustrating a conservative and cost-effective intervention for preserving a traumatically injured tooth in elderly individuals. Radiographic examination not only confirmed the fracture but also highlighted the prior successful endodontic treatment, observing a normal periodontal ligament. The ultraconservative approach included meticulous post-preparation in two-thirds of the root canal space, insertion of a prefabricated post, and reattachment of the fragment using a resin composite. The primary outcome showcased the successful adhesive reattachment of the fractured crown, preserving function, aesthetics, and tooth structure. This approach underscores the viability of preserving traumatized teeth in older individuals with a history of endodontic treatment, emphasizing both clinical success and cost-effectiveness.

## 1. Introduction

Coronal fractures of anterior teeth resulting from traumatic injuries are widespread across diverse age groups. Maxillary central incisors, with their proclined angulation, are particularly prone to such fractures, leading to challenges in phonetics, function, and aesthetics. Swift attention is crucial to mitigate structural, functional, and psychological impacts. Achieving optimal therapeutic outcomes necessitates a multidisciplinary approach involving all dental specialties and utilizing available materials to preserve dental tissues—an essential objective in the conclusive stages of treatment.[1]

However, recent advancements in acid-etching techniques and dentinal adhesives have spurred an increase in minimally invasive approaches among dentists, extending to tooth reattachment procedures.[2] While universal complex treatments such as tooth extraction and replacement, along with multidisciplinary approaches, may be time-consuming, expensive, and aesthetically unsatisfactory, simpler treatments offer a diverse array of options—from composite resin restoration to fragment reattachment. From a psycho-sociological perspective, the latter option presents advantages for the patient, providing immediate rehabilitation using their tissue.[3] This technique ensures complete aesthetic restoration, preserving all macroscopic tooth characteristics, including shape, contour, alignment, translucency, surface texture, and positioning.[4,5]

The success of the reattachment procedure is influenced by various factors, including the site and size of the fracture, root maturity, periodontal status, the choice of material, and pulpal involvement. Crown-root fractures are typically classified as complicated or uncomplicated based on pulp involvement. However, there are currently no such classifications for endodontically treated teeth globally. Complicated crown fractures involve enamel and dentin damage with pulp exposure, with trauma incidence ranging between 2-13%.[1] Common causes include falls, traffic accidents, domestic violence, fights, and sports-related injuries.

In complicated coronal fractures, the reattachment of fractured tooth fragments emerges as a favorable and conservative treatment modality. This article outlines the successful treatment of a fractured maxillary central incisor through a straightforward reattachment procedure.

## 2. Case Description

A 56-year-old male was referred to our private dental clinic due to a complete crown fracture in tooth 21 following a fall in his home yard. The affected tooth had undergone endodontic treatment ten years ago (Fig. 1A). Extra-oral examination revealed no significant findings. Intra-oral assessment unveiled an oblique fracture extending subgingivally, with the palatal margin approximately 2 mm from the free gingival margins (Fig. 1B). The patient provided a fragment retrieved from the incident, which was maintained in a dry condition (Fig. 1C). Radiographic examination not only affirmed the clinical diagnosis of an endodontically treated tooth 21 with an oblique complicated crown-root fracture but also demonstrated the success of the prior endodontic treatment (Fig. 1D). As there were no wounds, tetanus prophylaxis was not deemed necessary. The final diagnosis was an endodontically treated tooth 21 exhibiting an oblique complicated crown-root fracture.

Various treatment options were presented, including tooth extraction and replacement with an implant, periodontal surgery followed by prosthetic post and crown replacement, orthodontic

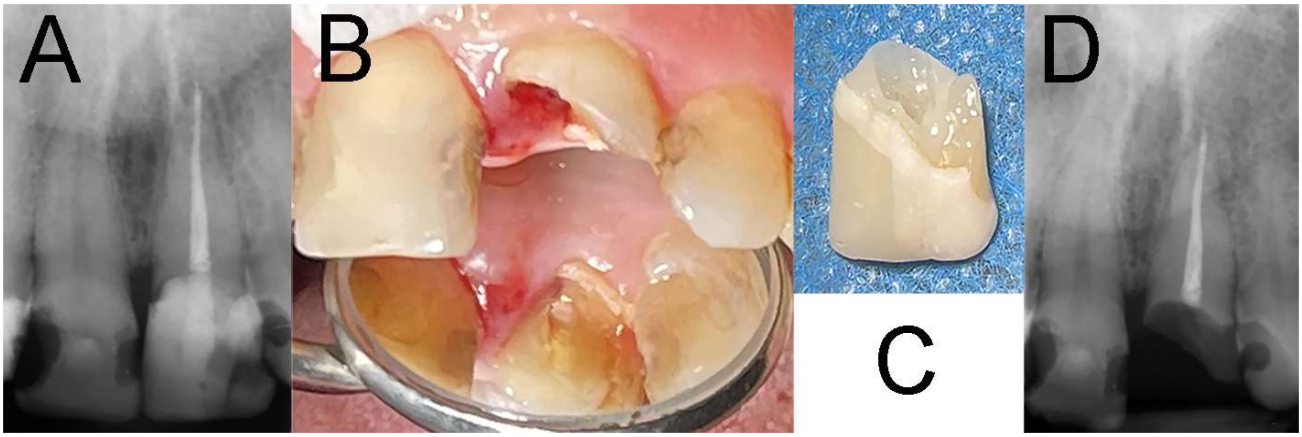


**Fig. 1.** Pre-operative radiographs and images illustrating the case of a 56-year-old male with a complete crown fracture in tooth 21: A) A periapical radiograph before the trauma showing the fractured tooth 21had undergone endodontic treatment ten years ago. B) Intra-oral view revealing the oblique fracture of tooth 21, extending subgingivally, with the palatal margin ~2 mm from the free gingival margins. C) Fragment retrieved from the incident, maintained in a dry condition. D) Radiographic examination confirming the clinical diagnosis of an endodontically treated tooth 21 with an oblique complicated crown-root fracture, demonstrating the success of the prior endodontic treatment.

forced eruption followed by prosthetic post and crown replacement, or a straightforward immediate reattachment. After a meticulous evaluation of the fragment condition and fit, the decision was made in favor of reattachment. The patient opted for reattachment, and informed consent was obtained before initiating the procedure. No relevant medical or dental history was identified.

The fractured segment, retrieved by the patient immediately after the trauma, was meticulously preserved in normal saline during the time between the clinical examination and reattachment, which took approximately 20 minutes. The treatment commenced with the cauterization of the free gingiva

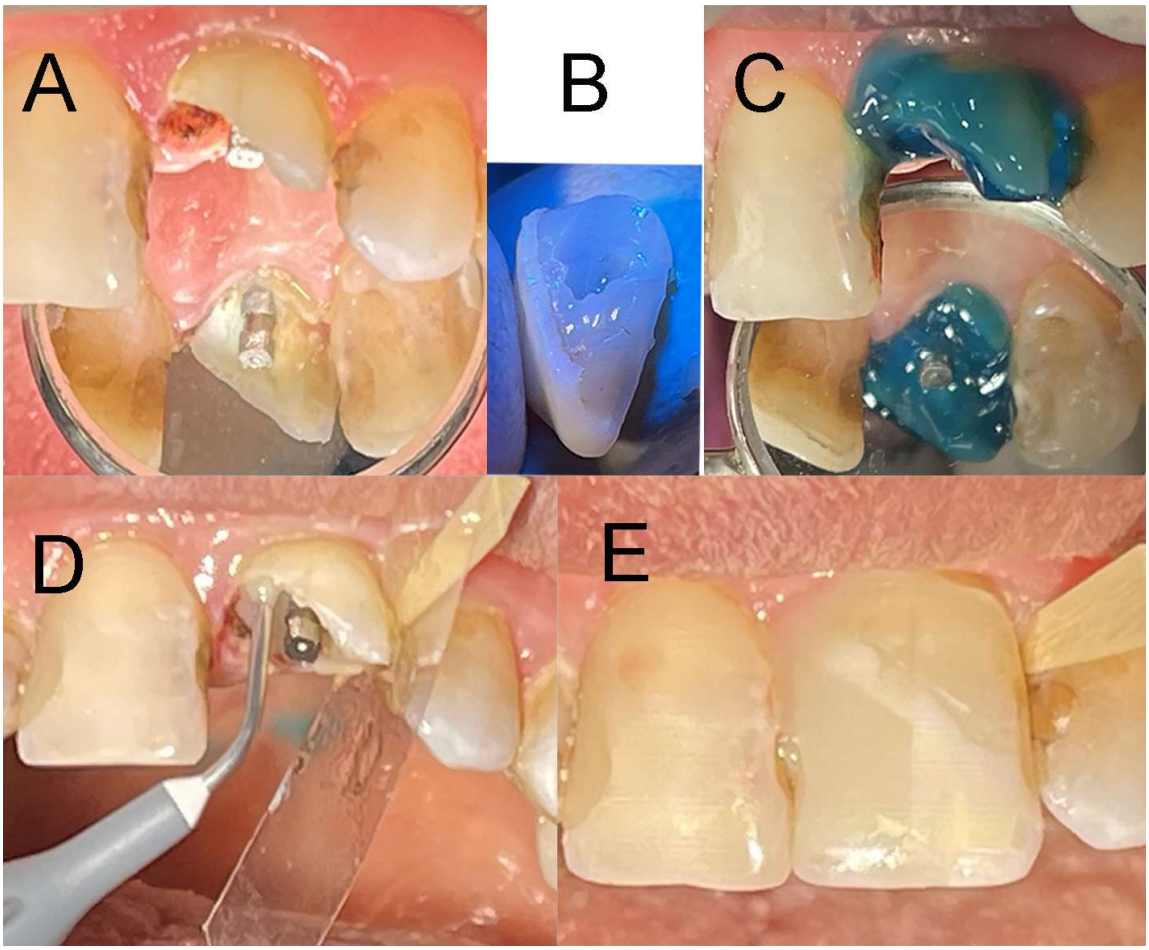


**Fig. 2.** Illustration of the treatment steps for the adhesive reattachment of the fractured crown in tooth 21: A) Meticulous post space preparation in two-thirds of the root canal space, ensuring proper fit and stability of the prefabricated post. B) Preparation of the fractured segment, including etching, rinsing, drying, and application of a light-curing bonding system in readiness for reattachment. C) Similar preparation steps repeated for the remaining tooth structure. D) Application of flowable resin-based dental composite restorative material for the reattachment of the fractured crown. E) Successful reattachment of the fractured crown without the need for surgical procedures, showcasing the effectiveness of the ultraconservative approach.

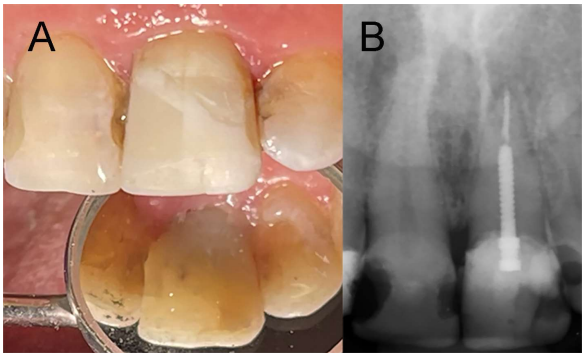


**Fig. 3.** Clinical follow-ups and radiographic evaluation after adhesive reattachment: A) clinical follow-ups with the patient expressing satisfaction regarding treatment. B) Radiographic evaluation after one year demonstrating successful results.

(under local anesthesia), followed by the detailed preparation of the post space in two-thirds of the root canal space using Gates Glidden burs #2-4 (DiaDent Group International, Korea), minimizing the removal of tooth structure. Given the subgingival nature of the fracture, the decision not to apply a rubber dam was made, considering that its use in this case might introduce further trauma to the gingiva. Subsequently, a prefabricated conical screw post (Long 2; Dental, Nordin, Swiss) was inserted and cemented using glass ionomer cement (Fuji II, GC Europe NV Leuven, Belgium), ensuring meticulous post space preparation for the proper fit and stability of the prefabricated post (Figure 2A). Despite the potential advantages of fiber posts, such as their ability to bond with tooth structure, it should be noted that in the present case, a metal post was preferred for its strength and stability.

The fractured segment underwent careful preparation to align with the remaining tooth structure and the inserted post. The prepared crown surfaces were then etched, rinsed, dried, and a light-curing bonding system (Scotchbond Multi-purpose; 3M, St. Paul, MN, USA) was applied in preparation for reattachment (Figure 2B). This process was replicated for the remaining tooth structure (Figure 2C). Utilizing flowable resin-based dental composite (3M ESPE, Seefeld, Germany) restorative material (Figure 2D), the crown was reattached without requiring surgical procedures (Figure 2E). The cauterization of the free gingiva played a pivotal role in maintaining a moisture-free environment during the procedure. Restorative margins were meticulously refined using diamond burs (KG Sorensen, Barueri, SP, Brazil), and occlusion adjustments were made to minimize occlusal interactions. The patient received explicit instructions to avoid exerting heavy pressure on the tooth and to adhere to proper oral hygiene practices.

Subsequent clinical follow-ups at regular intervals, conducted at three-month intervals, showcased positive patient feedback regarding the treatment and care received (Figure 3A). Throughout the follow-up period, there were no reported signs or symptoms, and radiographic evaluation after a year affirmed the success of the procedure (Figure 3B). Importantly, no adverse events were documented, solidifying the favorable outcome of the ultraconservative approach in managing the complete crown fracture.

## 3. Discussion

The ultraconservative reattachment approach demonstrated immediate treatment benefits, showcasing its efficacy in preserving traumatized teeth in older individuals with a history of previous endodontic treatment. Despite challenges posed by fractures extending subgingivally, satisfactory outcomes were achieved without resorting to surgery, thanks to the meticulous treatment protocol and the application of cauterization of the free gingiva. The simplicity of the reattachment procedure, along with immediate restoration, supported the observed clinical success over time.

When a tooth fragment is available, reattachment is the preferred approach; in cases where the fragment is not available, covering the dentin with a glass ionomer or a bonding agent and composite resin is recommended.[1] If a post is needed to retain a crown in a mature tooth with complete root formation, root canal treatment remains the preferred method.[6] The utilization of a prefabricated post, combined with meticulous post-space preparation, played a critical role in reattachment and achieving long-term success. Metal posts, though strong and stable, may pose challenges in terms of esthetics due to their opacity and potential for displaying a metallic hue. The decision not to apply a fiber post in this case was based on considerations of strength and stability. However, the choice of post material should be tailored to the specific clinical scenario, and in the context of this case, a metal post was preferred for its strength.

In comparison with conventional composite restoration, tooth fragment reattachment offers conservatism, a favorable wear mechanism, color matching with the remaining crown portion, preservation of incisal translucency, maintenance of the same occlusal contacts and natural tooth contours, color stability of the enamel, as well as ease of treatment and cost-effectiveness.4.6 This highlights the multifaceted advantages of tooth fragment reattachment, emphasizing its superiority over traditional composite restoration methods. The conservative nature of reattachment not only preserves tooth structure but also enhances aesthetic and functional outcomes, making it a valuable option in cases of crown fractures.

In treating anterior tooth trauma, especially common in children and young adults, the ultraconservative reattachment approach offers advantages. Young individuals benefit from higher tissue regenerative potential, predictable pulpal, and periodontal healing, and enhanced aesthetics with natural tooth structure preservation. Factors affecting the treatment approach differ between age groups. Young individuals may have ongoing tooth development and a more resilient periodontium, influencing treatment decisions. The psychological impact of trauma and the importance of immediate restoration for psychosocial well-being are significant considerations in this demographic.

In this case, no preparation on the tooth surface or fragment, such as beveling, was performed. This decision was based on the consideration that the ultraconservative reattachment approach aims to preserve the maximum amount of tooth structure.[1] Beveling, although a common technique in certain restorative procedures, was intentionally avoided in this case to minimize the removal of healthy dental tissues. The goal was to achieve a conservative restoration that maintains the natural tooth contour, alignment, and translucency without compromising structural integrity.

Regarding the choice of flowable resin composite for reattachment, we selected this material due to its specific properties aligning with the requirements of the ultraconservative approach.[4] Flowable resin composites offer low viscosity, enabling easy adaptation to irregularities and ensuring a close fit between the fractured segment and the remaining tooth structure. The material's flowability allows for precise placement and minimizes the risk of voids, contributing to improved marginal integrity. Additionally, flowable resin composites exhibit good adhesive properties, promoting effective bonding between the tooth surfaces and the reattached fragment.[4] The adhesive strength is essential for the long-term stability and durability of the

restoration. Moreover, the material's optical characteristics, such as translucency and color matching, contribute to achieving aesthetic outcomes by closely mimicking the natural tooth appearance.

Acknowledging limitations, the success of the ultraconservative reattachment approach is influenced by fracture extent, location, patient variables, and clinician expertise. Limitations include the decision not to use a rubber dam, potential esthetic concerns with metal posts, and other factors discussed in the case report.

## 4. Conclusion

Our study demonstrates the effectiveness of an ultraconservative reattachment approach in managing complete crown fractures, particularly in older individuals with a history of endodontic treatment. The meticulous treatment protocol, including cauterization of the free gingiva, and the utilization of a prefabricated post with a precise post space preparation, achieved immediate and sustained clinical outcomes. In addition, this ultraconservative method not only preserves tooth structure but also provides favorable aesthetic and functional results, underscoring its superiority over traditional composite restoration methods or other complex treatments for replacing the fractured tooth i.e. implant. The multifaceted advantages, including conservatism, color matching, and ease of treatment, make tooth fragment reattachment a valuable option for cases of crown fractures. Our findings support the importance of immediate restoration in successfully managing complicated crown-root fractures.

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