

The Effect of Tooth Location on the Success and Failure of Endodontic Treatment: A Systematic Review

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Abstract

Endodontic treatment is preferred to save the inside of the tooth, which is being infected by bacteria. There are many factors that can influence the outcome of an endodontic treatment. One of the most challenging factors is the anatomy of the tooth itself on which the endodontic treatment is planned. The location and type of tooth and structure of the root canal influence the anatomy of the tooth. This study aims to determine the effect of tooth location on the success rate of an endodontic treatment from the existing literature. Eight studies were included in this review with a total sample size of 6,056 patients who underwent endodontic treatment. All studies showed the outcome of endodontic treatment in the context of tooth type. Studies were consistent with the fact that the overall success rate of endodontic treatment is higher in anterior incisors as compared to premolars and molars owing to the number of canals per tooth and the comparative operational difficulty between incisors and molars while performing an endodontic treatment. Therefore, the findings in this review suggest that tooth location is a significant factor that can influence the outcome of endodontic treatment.

Keywords: Endodontics, Tooth location, Root canal treatment, RCT, Tooth type.

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INTRODUCTION

Endodontic treatment is a dental procedure designed to address the presence of infection or inflammation within the dental pulp, a soft tissue structure located within the tooth that houses blood vessels and nerves. Endodontic treatment, commonly referred to as “root canal treatment,” entails the extraction of the infected or inflamed pulp from the root canal system. This system spans from the tooth's crown to the root's tip [1]. Following the process of cleansing and disinfecting the root canal system, the dental professional, specifically the dentist or endodontist who specializes in endodontic treatment, proceeds to fill and seal the void using a substance known as gutta-percha. Subsequently, the tooth is subjected to a restorative procedure involving the application of a filling or a crown, thereby safeguarding it against subsequent harm

and reinstating both its functionality and aesthetic appeal.

Endodontic treatment is considered necessary in situations in which the dental pulp has been damaged as a consequence of bacterial infiltration. This can occur as a consequence of dental caries, fractures, trauma, or any number of other etiological reasons. The infection has the potential to spread to adjacent tissues in the absence of appropriate medical intervention, which can result in the manifestation of symptoms such as discomfort, inflammation, the formation of pus-filled cavities, and potentially even the loss of the tooth that is being affected [2]. Endodontic therapy has the potential to maintain the health of the patient's natural tooth, thereby eliminating the need for the tooth to be extracted and replaced with a dental prosthesis or another natural tooth.

Endodontic treatment is normally carried out with the assistance of local anesthesia, which ensures the patient will have as little discomfort as possible during the procedure. According to Santos-Junior *et al.*, [3], the success rate of endodontic treatment is greatly elevated, and the majority of treated teeth display a lifetime comparable to that of unaffected natural teeth when appropriate maintenance is observed. However, it is vital to realize that there are cases in which endodontic treatment may prove ineffective or demand repetition as a consequence of variables such as persistent infection, insufficient root filling, leaking in the crown, or tooth or root fracture. It is for this reason that it is essential to acknowledge that there are instances in which endodontic treatment may prove unsuccessful or necessitate repetition. The presence of periodontal disease, poor coronal restoration, and inadequate root canal preparation are some of the additional factors that can contribute to the failure of endodontic treatment. Additionally, it has been discovered that molars demonstrate a larger susceptibility to failure compared to anterior teeth [4]. This is the case because molars have more surface area to interact with food.

The primary objective is to mitigate pain, halt infection, and preserve the integrity of the natural tooth composition. The success of endodontic therapy continues to exhibit variability, despite advancements in techniques and materials [5]. This variability can be attributed, in part, to various factors, including the location of the tooth. This systematic review aims to investigate the impact of tooth location on the outcomes of endodontic treatment, with the aim of providing empirical evidence to support informed decision-making in clinical settings.

Justification of the research

According to the American Association of Endodontists, 15 million patients undergo endodontic treatment each year [2]. With thousands of endodontic treatments being performed each day on average, it is essential to understand the factors that can influence the outcome of endodontic treatment. One challenging factor is the tooth location prior to the endodontic treatment.

Aims of the study:

To investigate the relationship of tooth location on the outcome of endodontic treatment.

MATERIALS AND METHODS

Data Sources and Search Strategy

A comprehensive literature search for eligible studies was conducted in accordance with the PRISMA recommendations [6]. All the relevant articles assessing the condition of the tooth after an endodontic treatment on a follow-up indexed from December 2002 to July 2023 were retrieved by searching the following electronic databases: PubMed (Medline), Scopus, and the Cochrane Library. Additional articles were manually identified by screening the reference lists of obtained

studies and similar clinical trials to ensure all potentially relevant publications were included.

To carry out a thorough and organized search of the literature, a structured method was utilized using appropriate search terms, Boolean operators, and wildcard searches.

The following main ideas were considered for the search: Location of Teeth: The terms "tooth location," "tooth site," "tooth position," "dental arch location," "maxillary teeth," and "mandibular teeth" were utilized to encompass different positions and orientations of teeth. Endodontic Treatment: The search included terms such as "endodontic therapy," "root canal treatment," "root canal therapy," "pulpectomy," "apicoectomy," "endodontic success," and "endodontic failure" to cover different aspects of endodontic procedures and their outcomes. Success and Failure: To find relevant studies that focus on treatment outcomes, the terms "outcome assessment," "treatment outcome," "treatment success," "treatment failure," "clinical success," and "clinical failure" were included. Boolean operators (AND, OR, NOT) were used to effectively combine these search terms. The use of 'AND' helped narrow down the search results by requiring all specified terms to be present in the retrieved articles. 'OR' was used to broaden the search by accepting articles containing any of the specified terms, ensuring a comprehensive search. Additionally, the 'NOT' operator was used to exclude studies that were not directly related to our research focus. Furthermore, wildcard searches were conducted using asterisks (*) to account for variations in word endings and improve the sensitivity of the search. For example, 'endodont*' was used to retrieve articles with terms such as 'endodontic,' 'endodontists,' and 'endodontics.'

Inclusion Criteria

Studies were included according to the following criteria:

- Studies that investigate the impact of tooth location & type on the outcome of endodontic treatment.
- Studies written in English.
- Studies conducted on human subjects.
- Studies published in the period of 2003-2023.

Exclusion Criteria

Studies were excluded based on the following criteria:

- Review articles, meta-analysis, editorials, letters, case reports and conference abstracts.
- Studies that investigate the outcome of endodontic treatment on the basis of factors other than tooth location and type.
- Studies in languages other than English.
- Studies on non-human subjects.

Data Extraction

A short-listing process of studies based on their titles and abstracts was conducted, adhering to the established inclusion criteria. Duplicate studies were eliminated using Endnote X7 (Clarivate Analytics, PA). The full texts of articles that satisfied the eligibility criteria were thoroughly assessed. The results were compared side by side, and any discrepancies were resolved by consensus. The data extracted from the studies encompassed various study characteristics. These included details about the study author, publication year, study design, setting, sample size, follow-up period specifics, results, and demographic information of participants, such as age and dental health.

Quality Assessment:

The quality assessment of the study by Marques *et al.*, [7] was done using Cochrane's Risk of Bias 2.0 tool for Randomized controlled trials (RCTs) [8]. The visualization of the results of ROB2 as shown in Figure 1 was developed using ROBVIS tool [9]. For evaluating the methodology of observational cohort studies, the Newcastle-Ottawa scale was used [10] while the quality assessment of observational cross-sectional studies was done using the Newcastle-Ottawa scale adapted for cross-sectional studies. The results of quality assessment are shown in Figure 1, **Error! Reference source not found.** and Table 2.

Table 1

| Study Author | Year of Study | Study Title | Study Location | Study Design | Total Number of Patients | Outcome |
|----------------------------------|---------------|---|----------------|-----------------------------------|--------------------------|---|
| Laukainen <i>et al.</i> , [13] | 2021 | Radiographic outcome of root canal treatment in general dental practice: tooth type and quality of root filling as prognostic factors | Italy | Retrospective cohort study | 426 | The overall success rate of root canal treatment was determined to be 67.4% with success rates pertaining to various tooth types observed to be 76.8% for anterior teeth, 69.7% for premolars, and 55.6% for molars. In the analytical context, root canal treatments (RCTs) exhibited a greater probability of achieving favorable outcomes in non-molar regions, as indicated by an odds ratio (OR) of 1.8. |
| Huumonen <i>et al.</i> , [17] | 2012 | Radiographic assessments on prevalence and technical quality of endodontically-treated teeth in the Finnish population, aged 30 years and older | Finland | Survey | 3199 | The study revealed that the overall technical quality of endodontic treatment was deemed satisfactory in 47% of the total cases examined. Specifically, satisfactory outcomes were observed in 71% of anterior teeth, 51% of premolars, and 25% of molars. |
| Tang <i>et al.</i> , [14] | 2011 | Tooth anatomy risk factors influencing root canal working length accessibility | China | Retrospective observational study | 1005 | The success rate of endodontic treatment on anterior teeth was found to be 93.43%, whereas premolars exhibited a success rate of 88.10% and molars demonstrated a success rate of 84.43%. |
| Marques <i>et al.</i> , [7] | 2022 | Reciprocating instrumentation for endodontic treatment of primary molars: 24-month randomized clinical trial | Brazil | RCT | 137 | There was a diminished rate of successful outcomes in endodontic treatment for primary molars. There was 57.3% endodontic treatment success rate in primary molars utilizing reciprocating instrumentation (RECIP) techniques, while manual instrumentation techniques yielded a treatment success rate of 55.3%. |
| Nagasiri and Chitmongkolsuk [15] | 2005 | Long-term survival of endodontically treated molars without crown coverage: a retrospective cohort study | Thailand | Retrospective cohort study | 220 | The longitudinal assessment of endodontically treated molars without crowns revealed a decline in the overall survival rate over time. Specifically, the treatment success rate was observed to be 96%, 88%, and 36% at 1, 2, and 5-year follow-up intervals subsequent to the procedure. |

Table 1: Newcastle Ottawa scale of quality assessment for Cohort Studies

| STUDY | SELECTION | | | | COMPARABILITY | OUTCOME | | | QUALITY |
|-------------------------------------|----------------------------------|---------------------------------|---------------------------|--|---------------|-----------------------|--|----------------------------------|----------|
| | Representation of exposed cohort | Selection of non-exposed cohort | Ascertainment of exposure | Demonstration that outcome of interest was not present at start of study | | Assessment of Outcome | Was follow-up long enough for outcomes to occur? | Adequacy of follow-up of cohorts | |
| Ferrari <i>et al.</i> , 2007 [11] | 0 | 0 | 0 | ☆ | ☆ | 0 | 0 | ☆ | Poor |
| Laukainen <i>et al.</i> , 2019 [12] | 0 | 0 | ☆ | ☆ | NA | 0 | 0 | ☆ | Poor |
| Laukainen <i>et al.</i> , 2021 [13] | ☆ | 0 | ☆ | 0 | ☆☆ | 0 | ☆ | 0 | Moderate |
| Tang <i>et al.</i> , 2011 [14] | ☆ | 0 | ☆ | 0 | NA | ☆ | 0 | ☆ | Moderate |
| Nagasiri <i>et al.</i> , 2005 [15] | ☆ | 0 | ☆ | 0 | ☆ | 0 | ☆ | 0 | Moderate |

Table 2: Modified Newcastle Ottawa scale of quality assessment for Cross-sectional Studies

| STUDY | SELECTION | | | | COMPARABILITY | OUTCOME | | QUALITY |
|------------------------------------|----------------------------------|-------------|-----------------|---|---------------|-----------------------|------------------|---------|
| | Representativeness of the sample | Sample size | Non-respondents | Ascertainment of the exposure (risk factor) | | Assessment of Outcome | Statistical test | |
| Rao <i>et al.</i> , 2023 [16] | ☆ | ☆ | 0 | ☆☆ | NA | ☆ | ☆ | Good |
| Huunonen <i>et al.</i> , 2012 [17] | 0 | 0 | 0 | ☆ | NA | ☆ | ☆ | Poor |

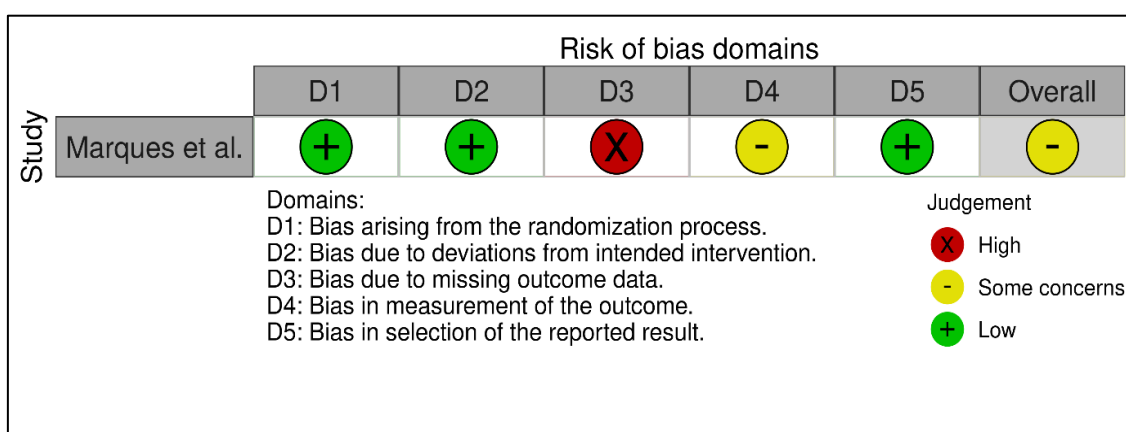


Figure 1: Cochrane Risk of Bias 2.0 tool for quality assessment of the study by Marques *et al.*, [7] Visualization is by ROBVIS tool

RESULTS

An initial search of the PubMed/Medline, Scopus and Cochrane CENTRAL library databases

yielded a total of 1,108 articles. After exclusion on the basis of title, abstract, and full text, a total of 8 studies were deemed eligible for inclusion in the systematic review. Figure 2 shows the PRISMA flow chart

summarizing the study selection process. These studies comprised six observational studies and two randomized controlled trials including a total sample size of 6,056

patients. The earliest study was published in 2005 and the latest study was published in 2023.

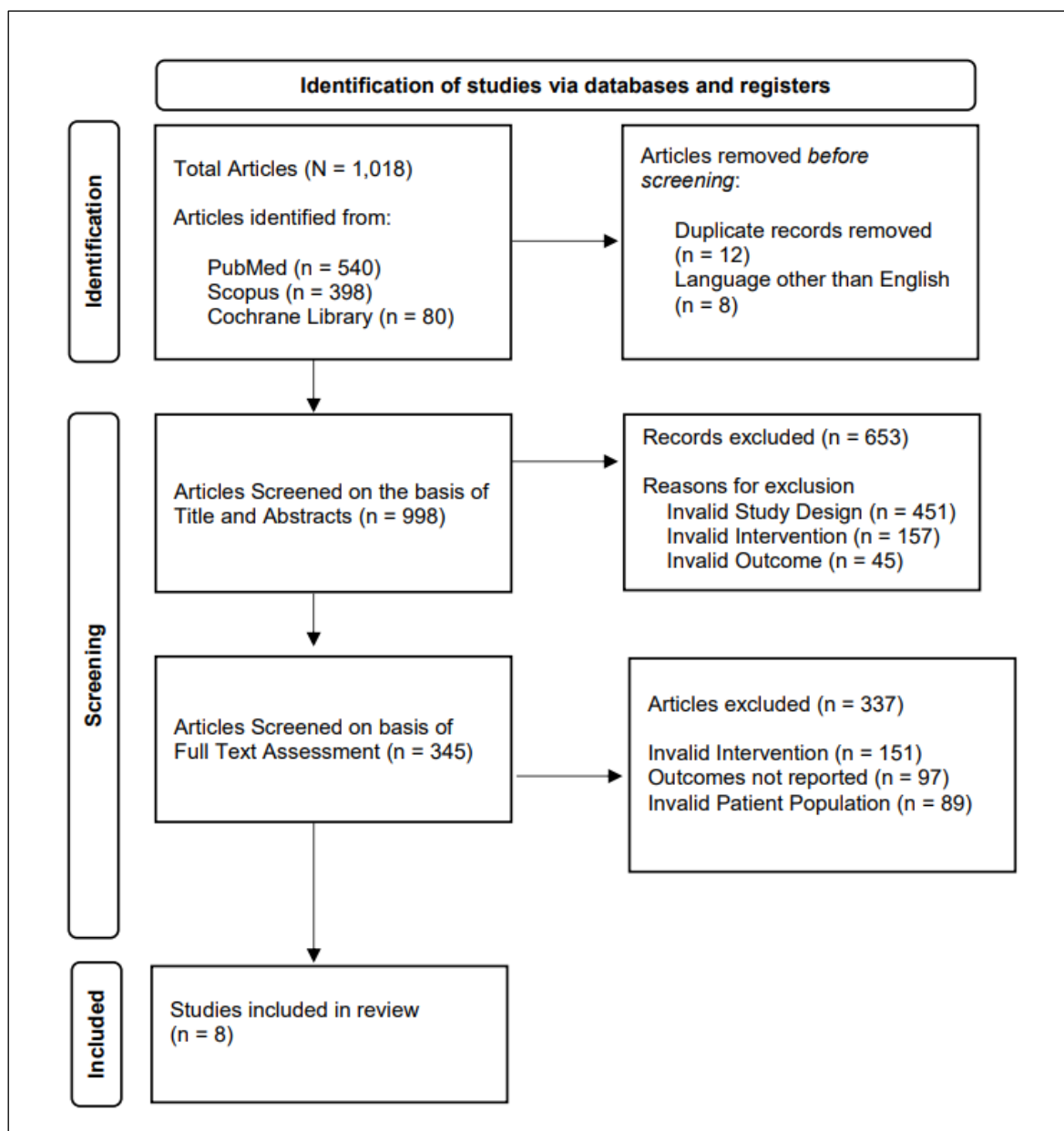


Figure 2: PRISMA Flow Diagram of Search Strategy

Table 3: Summary of Studies Evaluating the Effect of Tooth Location/Type on the Outcome of Endodontic Treatment

| Study Author | Year of Study | Study Title | Study Location | Study Design | Total Number of Patients | Outcome |
|------------------------------|---------------|---|----------------|--------------|--------------------------|---|
| Ferrari <i>et al.</i> , [11] | 2007 | Post placement affects survival of endodontically treated premolars | Italy | RCT | 210 | The survival rate of premolars that received endodontic treatment and were subsequently crowned was found to be 81.3% over a two-year period with a notable decrease in the likelihood of failure for premolars that have undergone endodontic treatment. |

| Study Author | Year of Study | Study Title | Study Location | Study Design | Total Number of Patients | Outcome |
|--------------------------------|---------------|--|----------------|-----------------------------------|--------------------------|---|
| Laukennan <i>et al.</i> , [12] | 2019 | Impact of type of tooth on outcome of non-surgical root canal treatment | Italy | Retrospective observational study | 640 | Root canal treatments (RCTs) have a greater probability of success in anterior teeth and premolars when compared to molars with success rates (SRs) of 85.6%, 88.8%, and 79.7% for the anterior teeth, premolars, and molars, respectively. |
| Rao <i>et al.</i> , [16] | 2023 | Incidence of Endodontic Failure Cases in the Department of Conservative Dentistry and Endodontics, DY Patil School of Dentistry, Navi Mumbai | India | Observational cross-sectional | 219 | The highest number of teeth that were reported to have failed after endodontic treatment were the molars (67.6%), followed by the premolars (14.0%), the incisors (12.8%), and finally the canines (5.6%). According to the location of the teeth that were impacted, the highest number of teeth that presented with a failed root canal treatment were from the mandibular posteriors (51.2%), followed by the maxillary posteriors (31.60%), the maxillary anterior (13.2%), and the mandibular anterior (4.0%). |

These findings provide an insight into the impact of tooth location including the anatomy of the tooth on the outcome of endodontic treatment and highlight the importance of considering tooth anatomy and its location prior to the endodontic treatment as these factors can significantly influence the outcome of the procedure and failures might lead to retreatments.

4. DISCUSSIONS

This systematic review includes studies that offer useful insights into the influence of tooth location on the success of endodontic treatment. These papers were added to the review. According to the findings of Ferrari *et al.*, [11], there was a considerable reduction in the chance of failure observed in premolars that had undergone endodontic treatment and were subsequently restored with crowns. This was shown in cases where the premolars had been restored with crowns after receiving endodontic therapy. This demonstrates how important it is to have proper restoration done after having root canal therapy done in order to ensure successful outcomes. This was also endorsed by the findings of Laukennan *et al.*'s (2019) research [12]; the success rates were much greater in the anterior teeth and premolars as compared to the molars. In addition to that, these results were also similar to a long-term follow-up examination that was carried out by Nagasiri and Chitmongkolsuk [15]. The findings of this inquiry revealed a steady drop in the rates of treatment success for molars that had undergone endodontic therapy. It is because anterior teeth and incisors exhibit a reduced number and less complex

configuration of root canals in comparison to molars, thereby rendering them more amenable to effective cleaning and subsequent filling procedures. Molars exhibit a higher degree of intricacy in their root canal anatomy, characterized by the presence of multiple canals, branches, curvatures, and isthmuses. This heightened complexity poses challenges in endodontic procedures, as it amplifies the difficulty in achieving comprehensive disinfection or proper filling of the root canal system [11]. This highlights the inherent problems connected with treating posterior teeth, which can be related to the complicated root canal anatomy and the obstacles involved in accessing and instrumenting these teeth. This finding also highlights the inherent difficulties associated with treating molars, which can be found here.

Both Rao *et al.*, [16] and Laukennan *et al.*, [13] also found that the results of endodontic treatment varied significantly depending on the type of tooth that was being treated. The research findings reveal that molars demonstrated the highest rate of failure following endodontic treatment, with mandibular posterior teeth being particularly sensitive to such failures, as indicated by the findings of these studies. The success rates were significantly greater in anterior and premolar teeth compared to molars. This discovery underscores the importance of customizing treatment plans to account for the unique qualities possessed by each distinct type of tooth.

In their study, Huumonen *et al.*, [17] investigated the technical quality of endodontic treatment, with a special emphasis on the potential differences that may occur based on the kind of tooth and the gender of the patient. The fact that the front teeth displayed the most positive outcomes compared to the molars, which demonstrated the least effective rates, highlights the challenges that are inherent in the management of intricate root canal systems. There were differences in the success rates of treatment between males and females depending on the position of the tooth, and these differences were observed to exist regardless of gender. In light of this, it is possible that there are biological and anatomical elements that can influence the outcomes of treatment. While the research that was carried out by Tang *et al.*, [14], it was confirmed that anteriors have higher treatment success rate than molars but in addition to that, this study also investigated the effect that the curvature of the root canal had on the success rates of endodontic therapy. When compared to teeth that displayed moderate or strong curvature, those that displayed a lower amount of curvature or none at all demonstrated much higher chances of success. The findings of this study were further substantiated by a retrospective analysis that examined the impact of root canal curvature on treatment efficacy. Teeth exhibiting no or minimal curvature demonstrated a success rate of 93.9%, whereas teeth with moderate curvature exhibited a success rate of 87.5%, and those with severe curvature exhibited a success rate of 81.8% [17]. As a result of this revelation, the importance of precision instrumentation and shaping procedures in curved canals for improving treatment outcomes has been brought to the forefront.

Marques *et al.*, [7] did a study to explore the usefulness of various instrumentation techniques in attaining satisfactory endodontic treatment outcomes in primary molars. The study looked at the effectiveness of these approaches. Due to the complexity of endodontic operations performed on primary molars, it was discovered that the success rates for both reciprocating instrumentation (RECIP) and manual approaches were quite low. Anterior teeth and incisors have a higher likelihood of receiving sufficient coronal restoration compared to molars, which is a favorable prognostic indicator for the outcome of endodontic treatment. The application of a coronal restoration serves to safeguard the tooth that has undergone endodontic treatment by preventing bacterial infiltration, minimizing the risk of fracture, and preserving its functional capabilities. Molars exhibit a heightened susceptibility to coronal deterioration, necessitating more comprehensive restorative interventions, such as the application of crowns or posts [18]. These procedures, however, may potentially compromise the structural integrity of the tooth and elevate the likelihood of endodontic treatment failure.

Molars exhibit a higher propensity for pre-operative apical periodontitis (AP) in comparison to anterior teeth, thereby serving as a negative prognostic indicator for the outcome of endodontic treatment. Apical periodontitis (AP) is characterized by a persistent or recurrent chronic infection in the tissues surrounding the root apex. This condition can occur even after root canal treatment, primarily due to the presence of microorganisms that are resistant to treatment, extraradicular biofilms, or reactions caused by foreign bodies. Apical periodontitis (AP) has been found to hinder the regenerative capacity of the tissues surrounding the apex of the tooth, thereby diminishing the overall effectiveness of endodontic therapy [19].

The overall findings of this research point to the fact that the position of the tooth plays a crucial part in deciding the success of endodontic treatment [13, 16]. In general, the success rates of front teeth and premolars are often higher in comparison to those of molars [12]. This disparity may be ascribed to variations in anatomy, challenges associated with reaching the teeth, and problems connected to curvature [14]. The success rates also vary depending on the quality of the instruments [7], the restoration, and the long-term follow-up care [15], which highlights the need for careful treatment planning and follow-up care in order to get the best potential results. Variations in endodontic treatment outcomes dependent on the location of the treated tooth have significant consequences for clinical practice. When planning and carrying out root canal procedures, practitioners should take into consideration the problems that are involved with the treatment of molars. These challenges include complex root canal anatomy and limited access. In order to increase the success rates in the posterior teeth, it may be necessary to make use of specialist instrumentation techniques and technology. Some examples of these include rotary files and cone-beam computed tomography (CBCT) imaging. In addition, the data highlight the significance of proper restoration and coronal sealing following endodontic treatment, particularly in premolars and molars, in order to lower the probability of the treatment failing.

Because the position of the tooth might affect the results of endodontic therapy, it is essential for dental practitioners to adequately communicate this information to their patients [20]. The patient's expectations can be better managed and more informed treatment decisions can be made if the patient is educated about the difficulties that are associated with treating various teeth as well as the potential success rates. Alternative treatments, including extraction followed by implant placement or fixed prosthesis, should be thoroughly discussed with the patient in instances where the prognosis for endodontic therapy in the molars is impaired. This may include situations in which the patient has a tooth that is severely decayed.

It is of the utmost importance to understand and appreciate the limitations and flaws that are inherently present in the studies that were included in this systematic review. There were several studies that had small sample sizes [7, 11], and there might be differences in the treatment protocols and the amount of time that participants were followed up for between the various research. In the future, researchers should make it a priority to carry out exhaustive experiments that involve several centers and make use of standardized procedures in order to obtain more substantial information regarding the influence of tooth location on the results of endodontic therapy.

Therefore, the purpose of this in-depth review was to highlight how important it is, when formulating a treatment strategy for endodontic operations, to take into account the precise position of the affected tooth. In general, the success rates of anterior teeth and premolars are often higher in comparison to those of molars [12, 14]. This may be because of anatomical variances and the fact that it is more difficult to access the molars. Implementation of proper restoration techniques, meticulous instrumentation, and regular follow-up procedures are required in order to achieve optimal treatment outcomes in a variety of tooth types. These are prerequisites for excellent treatment outcomes. When dental practitioners have a thorough understanding of these nuances, they are better able to personalize the treatment approaches they use, which results in an increase in the endodontic operations' overall level of success.

CONCLUSIONS

It can be concluded from this systematic review that tooth location has a significant impact on outcome of endodontic treatment and must be considered prior to the procedure. The findings highlight that the treatment success rate of endodontic treatment is higher in anterior maxillary or mandibular teeth as compared to the maxillary and mandibular premolars and molars.

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