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Impact of Orthodontic Tooth Movement on the Longevity of Endodontically Treated Teeth: A Prospective Clinical Study.

ABSTRACT
Modern dentistry is grounded in orthodontic therapies and endodontic work. The field of endodontics deals with the diseases of the pulp and roots of the teeth, whereas Orthodontics deals with the malalignment of teeth and jaw. They are combined with these treatments when there is some malocclusion or misalignment especially when they are endodontically treated (ETT). The effect of the orthodontic forces on the long-term and clinical outcomes of ETT is not well identified yet and there is a fear that the risk will be increased, which may include root and tooth mobility resorption. This study aimed to investigate the combined effects of orthodontic and endodontic treatments on the longevity and clinical outcomes of endodontically treated teeth (ETT), focusing on complications, treatment success, and patient satisfaction. A cross-sectional survey was conducted using a structured questionnaire with 120 participants (orthodontists, endodontists, and patients). Data were collected through both closed-ended and open-ended questions to assess participants' experiences, treatment outcomes, and complications. Descriptive statistics, Chi-square tests, correlation analysis, and linear regression were applied to analyze the data. The study found that 55.8% of participants received orthodontic treatment, and 82.5% had endodontic treatment. The treatment outcomes showed that 37.5% rated their treatment as successful, while 12.5% considered it very successful. Root resorption and tooth mobility were more common in those who received orthodontic treatment. A significant positive correlation was found between patient satisfaction and treatment outcomes. Linear regression analysis identified that orthodontic treatment, root resorption, and tooth mobility were key predictors of the longevity of ETT. The paper not only indicates the possibilities of effective combined therapies but also points out the dangers of adverse effects like root resorption. The orthodontists and endodontists must work together interdisciplinarily to reduce risks. The future research must be based on longitudinal studies and randomized trials to learn more about the long-term impact of orthodontic forces on ETT.

INTRODUCTION
Modern dental care is based on orthodontic and endodontic interventions. The major issue of orthodontics is how to correct the misalignment of the teeth and the jaws with the help of braces or other devices to change the position of the teeth, to improve the occlusion and also to increase the beauty.[1] The aim is to strive towards the attainment of improved functioning and the prevention of chronic dental problems, including malocclusions or even jaw pains. Endodontics, however, is a discipline that aims at the diagnosis and treatment of the diseases of the dental pulp and the root tissues.[2] Root canal therapy is the most popular treatment in the endodontics field; it is used to salvage teeth that have been affected by disease, damage, or infection. Root-treated (or endodontically treated) teeth (ETT) typically fall under the category of structurally weaker vital teeth as they have undergone the loss of the pulp, causing the decrease in blood supply and the shift of the mechanical properties.[3] Even though orthodontic treatments and endodontic treatments are used to serve different purposes, clinical situations arise where both treatments are

essential to a given patient. As an example, endodontically-treated teeth might be in need of orthodontic repositioning in order to address malocclusion or enhance bite alignment.[4,5] Nonetheless, the hybrid methodology poses a question regarding the sustainability of ETT in the long term because orthodontic forces can be used to worsen the existing weaknesses that result in complications like root resorption or fracture. Although both orthodontic and endodontic treatments are used widely, there is still no comprehensive knowledge of the combined effects of the orthodontic forces on the longevity of ETT, especially in comparison to the long term.[6] The impact of orthodontic forces on ETT is essential in facilitating clinical practice since such teeth might be susceptible to failures when orthodontic treatment is being administered than vital teeth.[7,8] It is still not well understood what the biological effects of the orthodontic forces on the maintained structure of ETT are, and therefore, there is a necessity to examine the potential effects of such forces on the long-term success and survival of these teeth.[9,10]

There is a large gap in the literature concerning the synergistic impact of orthodontic treatment on the duration of endodontic treated teeth. Although studies have been conducted to examine the effect of orthodontic forces on the vital teeth, not many studies have done the same on ETT.[11] Available literature on the same is mostly constrained by low sample sizes, limited time of follow-up and the fact that they have only looked at certain complications such as root resorption. As a result, no evidence exists on long-term survival and clinical outcomes of ETT exposed to orthodontic forces.[12] Moreover, the existing studies are mainly clinician-oriented, and very few views are contributed by the patients or practitioners dealing with these cases regularly as a normal practice.[13] Thus, it is urgent to perform the study in which expert opinions (orthodontists and endodontists) and patient-reported outcomes are considered to understand the combination of the effects of orthodontic and endodontic treatments even more comprehensively.[14,15] The proposed research will serve to address the research gap since it will explore the long-term effects of orthodontic tooth movement on the long-term and clinical performance of endodontically treated teeth.[16] This study will yield a better insight into the impact of forces in orthodontic on survival and structure of these teeth by collecting the insights of the dental professionals (orthodontists and endodontists) as well as the patients.[17,18]

The justification of a questionnaire-based method is to receive qualitative and quantitative data of the diverse group of professionals and patients. This kind of a survey would offer important information about the dangers and advantages of orthodontic combined with endodontic treatment, and also highlight some of the complications that may be encountered during orthodontics treatment.[19] The questionnaire is a suitable tool to use in this study due to its efficiency in collecting data involving a large population and scalability. The specified strategy will allow collecting the data regarding the experiences, treatment plans, and patient outcomes of the professionals in the 1:1 clinical setting. The given study will play a significant role in the effort to elucidate the clinical signs and problems of the ETT management in orthodontic forces by putting emphasis on the perspectives of orthodontists, endodontists, and patients. The results will be important in improving clinical decision-making and patient treatment of patients who receive orthodontic and endodontic treatments.

Research Objectives

1. To determine the views of orthodontists and endodontists on the effectiveness of orthodontic tooth movement on the survival of endodontically treated teeth.
2. To determine patient-reported outcomes of the longevity and clinical outcomes of endodontically treated teeth following the administration of orthodontic treatment.

METHODOLOGY

STUDY DESIGN

The study was based on a cross-sectional survey study design and a structured questionnaire to examine the interaction of the effects of orthodontic and endodontic treatment. All the participants including orthodontists, endodontists and patients provided informed consent and ethical consent. The survey was assured of confidentiality and voluntary participation of the participants.

SAMPLE SELECTION

The sample size that was used in the study was 120 that consisted of orthodontists, endodontists and patients who had undergone orthodontic and endodontic treatment. The inclusion criteria were orthodontists and endodontists with at least 3 years of clinical experience and patients who had both treatments within the past 5 years. The exclusion criteria were that the professional had to have less than 3 years of experience, and the patient had to have incomplete treatments or lack of follow-up data.

DATA COLLECTION

The structured questionnaire was used to collect data by including closed-ended and open-ended questions. Close-ended questions were based on Likert scale to assess the experiences and perception of the participants on the orthodontic forces on ETT whereas the open-ended questions were used to gather qualitative information on the outcomes of the treatment and complications. The questionnaire also included some patient demographics, treatment types, and complications experienced during orthodontic treatment of ETT.

DATA ANALYSIS

Responses were summarized with the help of descriptive statistics (frequencies, means). The chi-square tests were used to determine the relationship between the categorical variables of treatment and complications. Also, the correlation analysis was used to evaluate the relationships between patient satisfaction and treatment outcomes. The analysis was done using

linear regression analysis to find out the significant predictors of longevity of endodontically treated teeth.

ETHICAL CONSIDERATIONS

The research was conducted in accordance with ethical principles whereby all the respondents were informed consent and were informed of their right to pull out of the research any time without repercussions. Data were coded and kept in a secure location in order to preserve confidentiality.

RESULTS

DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS

The demographic factors of the participants in the study such as age, sex, profession and years of clinical experience were assessed. The sample was made up of a wide variety of participants, comprising of orthodontists and endodontists, and patients who had undergone both procedures. Most of the participants aged between 31-50 and the genders were balanced. The majority of the professionals were experienced in more than 3 years, which guaranteed a balanced perspective on clinical practices and patient outcomes (Table 1).

Table 1: Demographic Distribution of Study Participants

	Category	Frequency (%)	Number of Respondents
Age	Under 18	2.5%	3
	18-30	22.5%	27
	31-40	28.3%	34
	41-50	21.7%	26
	Over 50	25%	30
Gender	Male	53.3%	64
	Female	44.2%	53
	Prefer not to say	2.5%	3
Occupation	Orthodontists	39.2%	47
	Endodontists	36.7%	44
	Other	24.2%	29
Years of Experience	Less than 3 years	12.5%	15
	3-5 years	16.7%	20
	5-10 years	23.3%	28
	Over 10 years	47.5%	57

Figure 1 shows the demographic features of the study participants such as age, gender, occupation, and years of experience. These facts help to give the necessary background of the sample of participants.

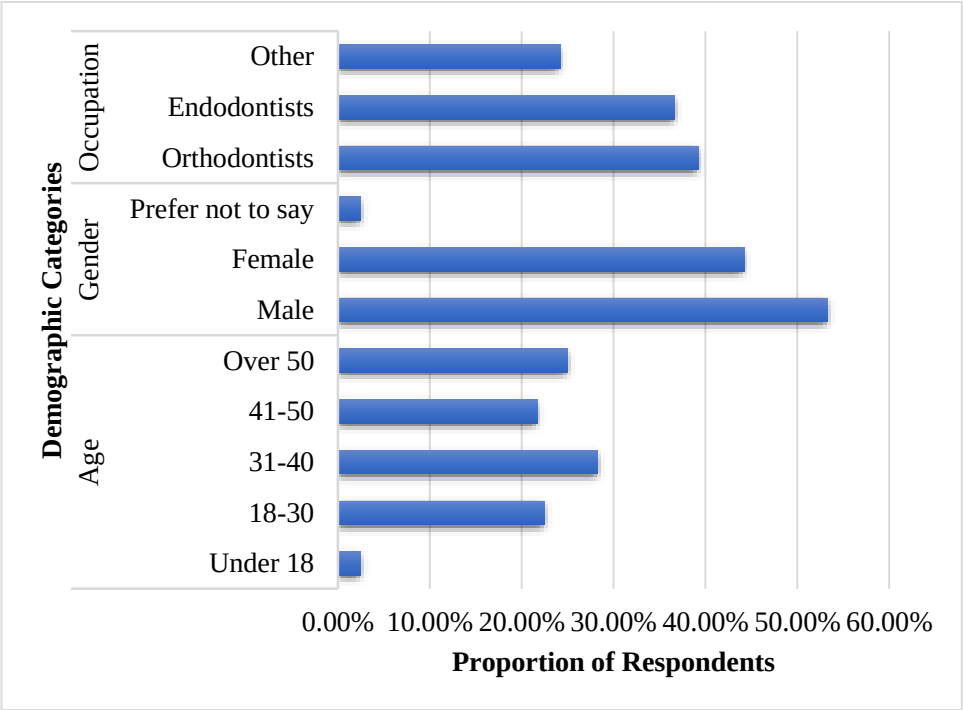

Figure 1. Distribution of Demographic Characteristics of Study Participants

Figure 1 shows that most of the participants fell within the age range of 31 and 50, with gender distribution being relatively equal. Professional experience-wise, a considerable proportion of the participants had more than 10 years of experience with endodontists slightly outnumbering orthodontists. These demographic details indicate that the sample is heterogeneous in the aspects of age and professional experience, which enhances the representativeness and applicability of the research results.

TREATMENT EXPERIENCE AND OUTCOMES

The respondents were questioned on their experience of orthodontic and endodontic treatments. A large percentage of the participants had positive results of the combined treatments with 55.8 percent of the participants undergoing orthodontic treatment and 82.5 percent undergoing endodontic treatment as indicated in Table 2. The results of the combination of the two treatments showed that the majority of patients rated their results as successful or very successful with only a minor proportion reporting unsuccessful or very unsuccessful results.

Table 2: Orthodontic and Endodontic Treatment Experience and Outcomes

	Category	Frequency (%)	Number of Respondents
Orthodontic Treatment	Received Orthodontic Treatment	55.8%	67
	Did not receive Orthodontic Treatment	44.2%	53
Endodontic Treatment	Received Endodontic Treatment	82.5%	99
	Did not receive Endodontic Treatment	17.5%	21
Outcome of Combined Treatments	Very successful	12.5%	15
	Successful	37.5%	45
	Neutral	20%	24
	Unsuccessful	17.5%	21
	Very unsuccessful	12.5%	15

Figure 2 shows the percentage of respondents who experienced these treatments, which gives a graphical depiction of the treatment experience among the study sample.

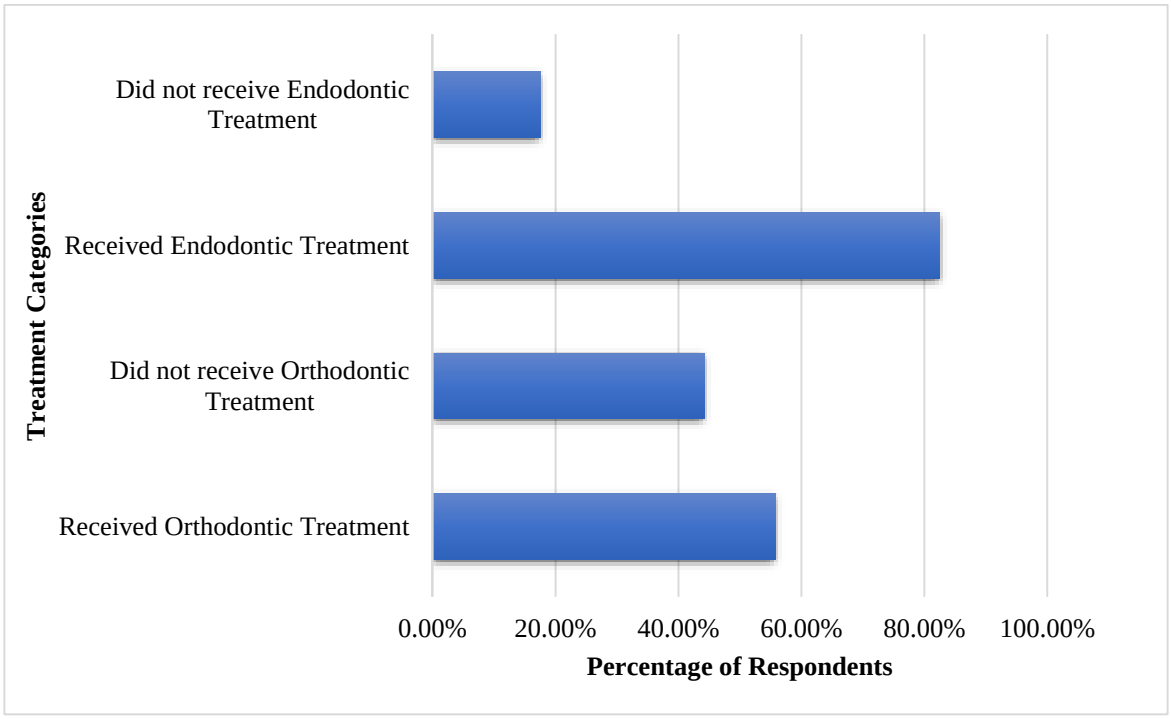

Figure 2. Distribution of Participants Based on Orthodontic and Endodontic Treatment Experiences

As depicted in Figure 2 above, 82.5 percent of the respondents had endodontic treatment, and 55.8 percent had orthodontic treatment. A significant number of the participants were treated to both and a smaller number was not treated to either of the treatments. This distribution underscores the fact that the study is

focusing on the participants who have undergone a combination of orthodontic and endodontic procedures, which is the center of the investigation of the long-term effects of these procedures.

IMPACT OF ORTHODONTIC TREATMENT ON COMPLICATIONS

The relationship between orthodontic therapy and occurrence of complications such as root resorption and mobility of teeth was investigated. There was a high level of correlation between the orthodontic treatment and the likelihood of developing complications like root resorption and tooth mobility (Table 3). These findings indicate that the application of orthodontic forces on endodontically treated teeth is a phenomenon that requires special consideration because complications directly affect the survival and functional outcomes of the treatment.

Table 3: Association Between Orthodontic Treatment and Complications

Complication	Orthodontic Treatment (Yes)	Orthodontic Treatment (No)	p-value
Root Resorption	40% (27)	17% (9)	0.03
Tooth Mobility	30% (20)	15% (8)	0.04
Fractures	6.7% (4)	5.4% (3)	0.72
No Complications	33.3% (22)	40% (21)	0.51

CORRELATION BETWEEN PATIENT SATISFACTION AND TREATMENT RESULTS

The analysis results revealed that the levels of satisfaction had a strong positive correlation with the treatment outcomes. The more contented the participants were, the higher the chances that they will report that their orthodontic and endodontic treatments were successful or very successful. Conversely, the complaining individuals were more likely to refer to the outcome as a failure. These findings suggest that patient satisfaction is a significant variable in the evaluation of the treatment effectiveness (Table 4).

Table 4: Relationship Between Satisfaction and Treatment Outcome

Satisfaction Level	Treatment Outcome	Pearson Correlation (r)	p-value
Very Satisfied	Very Successful	0.85	<0.01
Satisfied	Successful	0.72	<0.01
Neutral	Neutral	0.50	0.02
Dissatisfied	Unsuccessful	-0.45	0.01
Very Dissatisfied	Very Unsuccessful	-0.60	<0.01

PREDICTORS OF LONGEVITY OF ENDODONTICALLY TREATED TEETH (ETT)

The linear regression established that the longevity of endodontically treated teeth (ETT) has significant predictors. Orthodontic treatment, root resorption, and tooth mobility were identified to adversely affect the longevity of ETT as indicated in Table 5. Regression model describes 62 percent of the variation in the longevity of these teeth, which indicates the importance of orthodontic treatment in the long-term success of ETT.

Table 5: Linear Regression Analysis of Predictors for Longevity of ETT

Predictor	β-value	p-value
Orthodontic Treatment	-0.45	0.02
Root Resorption	-0.35	0.03
Tooth Mobility	-0.28	0.05
Treatment Sequence	0.12	0.52
R-squared	0.62	

DISCUSSION

The findings of this research are very informative on the synergistic impacts of orthodontic and endodontic therapies on the prognosis and clinical results of endodontically treated teeth (ETT). One of the findings was that a significant percentage of respondents who had undergone the two treatments had successful or very successful results. In particular, 37.5% of respondents considered the results successful, and 12.5% of them very successful, which shows the possibility of positive clinical outcomes in case orthodontic forces are used in endodontically treated teeth. 17.5% of them were unsuccessful, which highlights the risk of the combined method of treatment. It is noteworthy that such complications as root resorption and tooth mobility were more common among the individuals who had received orthodontic treatment with 40 percent of the respondents reporting root resorption as opposed to 17 percent of the individuals who had not received orthodontic treatment. The results are consistent with the existing literature that orthodontic forces may intensify the endodontically treated teeth weaknesses especially root resorption. Nevertheless, the research also highlights that effective treatment results can be obtained in case both orthodontic and endodontic procedures are properly handled, which proves that the

combination of the two treatments can be effective, though there are certain risks that can be taken into account.

The results of the current research are in line with the past studies on the effect of orthodontic therapy on the integrity of endodontically treated teeth. Research has indicated that orthodontic therapy may cause such complications as root resorption and tooth mobility, especially in endodontically treated teeth. Indicatively, it has been established that orthodontic forces may play a major role in external root resorption of root-filled teeth.[20] This is in line with our observation that root resorption was more common among individuals who had undergone orthodontic therapy. In addition, other studies have demonstrated that mobility of roots in orthodontically treated teeth may influence clinical outcomes, which is why our findings indicate a greater prevalence of tooth mobility in orthodontically treated subjects.[21] This emphasizes the need to measure the integrity of roots of endodontically treated teeth undergoing orthodontic forces. In addition, it has been proposed that the survival of endodontically treated teeth may be influenced by a number of factors, such as root resorption and tooth mobility, which are also important predictors in our regression analysis (e.g., orthodontic treatment and root resorption).[22] Our research is based on this, as it demonstrates that orthodontic treatment is a strong predictor of shorter longevity of ETT that is vital to inform clinical practice. Conversely, another study established that endodontic treatments using and without posts had satisfactory long-term clinical outcomes, yet this study did not determine the effect of orthodontic forces on the clinical outcomes.[23] The contrast underlines the role of taking into account orthodontic forces as another variable in the success of endodontically treated teeth in the long run.

Moreover, the recommendations regarding the management of the advanced periodontal disease imply that one should be cautious when applying several treatments (such as orthodontics and endodontics) simultaneously, which indirectly implies the possibility of complications when combining treatments.[24] This supports the need to know the effect of orthodontic forces on endodontically treated teeth. Finally, a meta-analysis highlighted the high risk of root resorption in both vital and endodontically treated teeth in the course of orthodontic treatment, which is consistent with our results on the increased risk of complications in endodontically treated teeth.[25]

The findings of this study are of great importance to clinical practice especially to patients who need both orthodontic and endodontic interventions. Since increased rates of root resorption and tooth mobility have been found in patients that underwent orthodontic treatment, clinicians should be careful when using orthodontic forces on endodontically treated teeth. Endodontists and orthodontists are supposed to work together in order to make sure that the right precautions are taken to reduce the chances of complications, which may include using less force in orthodontics or increased monitoring. The other significant issue that the research brings up is that the patients must be properly informed of the potential risks and benefits of such combinations of treatments. Successful treatment outcomes were strongly associated with patient satisfaction, which indicates that patient expectations and involvement are important to the overall success of the combined treatment strategy.

Although the research has some beneficial findings, it has a number of limitations that should be mentioned. To begin with, the study is cross-sectional, which restricts the possibility of making conclusions about the long-term outcomes of orthodontic forces on endodontically treated teeth. A longitudinal study would be more effective in giving more resilient data on long-term survival rates and complications of these treatments. Also, although the sample size was sufficient, the study was limited to a particular group of patients who have undergone both procedures, and this might not be a complete representation of all patients undergoing either orthodontic or endodontic treatment individually. The next study ought to take into account a larger and more diverse sample, which comprises of patients receiving only one of the treatments to compare the outcomes of the various groups.

The other weakness is that the research was dependent on patient-reported outcomes and clinician evaluations on subjective interpretations, which might create response bias. Radiographic examinations would give a more precise view of the complications related to orthodontic treatment as they are objective measures of treatment outcomes.

Future Scope

Long-term studies should be done in the future to monitor the long-term results of the patients undergoing both orthodontic and endodontic therapies. This would enable the researchers to determine the long-term effects of orthodontic forces on endodontically treated teeth. Also, randomized controlled trials (RCTs) may be more conclusive in stating the causal relationships between orthodontic treatment and such complications as root resorption and tooth mobility.

It would be worthwhile to examine the application of new orthodontic methods that reduce the chances of complications (e.g., less intense forces, individualized treatment plans). Lastly, larger and more varied populations in multicenter studies would assist in generalizing the results and give a better picture of how these treatments interrelate in different demographics.

CONCLUSION

The paper offers meaningful information on the overall impact of orthodontic and endodontic therapies on the survival and clinical success of endodontically treated teeth (ETT). The main results are that a large percentage of the participants have reported successful or very successful results of the combination of both treatments, with a small percentage having unsuccessful results. The root resorption and tooth mobility complications were more evident among individuals who received orthodontic treatment highlighting the risks that might be involved when subjecting the endodontically treated teeth to orthodontic forces. The research concluded that the level of satisfaction and the outcome of treatment showed a significant correlation thus indicating that

patient satisfaction is very important in measuring the effectiveness of combined treatments. The regression analysis showed that orthodontic treatment, root resorption, and tooth mobility were highly significant predictors of longevity of ETT, which supports the idea that orthodontic forces in patients with endodontically treated teeth should be carefully managed. Although the findings highlight the fact that combined therapies have a chance of success, they also highlight the importance of exercising extreme care and interdisciplinary cooperation between the orthodontists and the endodontists in order to reduce the complications. Further studies on the topic should be conducted in the form of longitudinal investigations and randomized controlled trials, which will allow better comprehending the long-term effects of orthodontic forces on endodontically treated teeth and creating more sophisticated treatment plans. The results of this research are critical towards enhancing clinical decision making and patient care to those who are undergoing orthodontic and endodontic procedures.

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