

Evaluation Of The Use Of Clinical Practice Guidelines For Managing External Apical Root Resorption By Orthodontists In Pakistan.

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Abstract

Background: External apical root resorption (EARR) is a common side effect of fixed orthodontic treatment, resulting from complex biological and mechanical processes involving the periodontal ligament and alveolar bone.

Objectives: To assess the current practices of orthodontists in Pakistan regarding diagnosis, risk communication, management, and follow-up of external apical root resorption using a questionnaire derived from the Dutch Clinical Practice Guideline.

Materials and Methods: A cross-sectional survey was conducted among orthodontists registered with the Pakistan Medical and Dental Council. The total study duration was three months (May–July 2025). A 13-item questionnaire based on the Dutch Clinical Practice Guideline was distributed online to orthodontists in Pakistan. Sample size estimation using G*Power ($\alpha = 0.05$, power = 0.80, effect size = 0.3) indicated that a minimum of 89 participants was required but, total of 101 orthodontists responded. Data were analyzed using SPSS. Descriptive statistics were computed, and Mann-Whitney U tests compared consultants and residents.

Result: Among 101 respondents, 64 were male and 37 were female, with most having less than five years of experience. Diagnostic awareness was 67.70%, and periapical radiographs were the preferred imaging method. Risk communication was 67.5%, as the majority informed patients about general and extraction-related risks. Management response reached 72.5%, with 40.6% very often stopping forces on affected teeth and 30.7% allowing a three-month rest period. Follow-up practices were 65.8%, including 43.0% retention reviews and 33.0% coordination with general dentists showing that both consultants and residents are weak in this domain. Consultants scored higher than residents in diagnosis and treatment management domains, reflecting adherence to clinical recommendations based on expertise.

Conclusions: Orthodontists in Pakistan follow an evidence-based and a conservative approach toward the management of external apical root resorption, showing good diagnostic awareness and patient communication; however, improvement is needed in coordination with general dentists among both consultants and residents. Consultants demonstrate stronger adherence to clinical guidelines than residents, highlighting the need to strengthen postgraduate training and interdisciplinary coordination with general dentists.

Keywords: External apical root resorption, Orthodontic treatment, Clinical practice guideline, Risk communication, Periapical radiograph, Cone beam CT(CBCT)

Introduction

One common and prevalent side effect of orthodontic therapy with fixed appliances is external apical root resorption (EARR).¹ The complex biological process that causes EARR includes various types of cellular, inflammatory and mechanical mechanisms.² The periodontal ligament and adjacent tissues may become inflamed as a result of orthodontic pressures. Specialized Osteoclasts cells involved in

bone resorption are activated by this inflammation and may unintentionally target the root surfaces resulting in root resorption. In this situation, molecular signals, including osteoprotegerin (OPG) and receptor activator of nuclear factor kappa-B ligand (RANKL), are essential for controlling osteoclastic activity. In terms of EARR and periodontal health, the PDL is crucial. The periodontal ligament integrity may be compromised by inflammatory processes linked to EARR which would impair teeth adhesion to the surrounding bone. Variability in EARR results has been linked to polymorphisms in genes related to immunological responses, inflammation, and bone remodeling. Studies have shown that the moderate forms of EARR are associated with 16 different variations, including TNFR F11B, VDR, IL1B, IL1RN, IL1A, OPG, RANKL, P2XR7, SPP1 and IRAK1.²

These genetic variables may affect a person's capacity to control osteoclastic activity, inflammatory reaction and repair process.³ More than 90% of all orthodontically manipulated teeth exhibit EARR histologi-

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cally. Clinically, less than 2.5mm of EARR exists in 48-66% of teeth. Although 1-5% of the patient will have an EARR of greater than 4mm or more than one third of the original length.^{3,4} certain factors, including tooth extractions, length of treatment, heredity, sex, and excessive orthodontic force, are believed to be associated with an increased risk of EARR. It is important to assess the patient's risk during treatment. However, their predictive value remains low, and orthodontists struggle to make evidence-based treatment decisions.^{1, 6} Two-dimensional (2D) radiography or three-dimensional (3D) cone beam computed tomography (CBCT) can be used clinically to detect EARR, or histologically by microscopy analysis.^{5,7} however, because of resolution in 3D, 3D imaging are more accurate and dependable than 2D techniques.^{5,8,9} The most common techniques for quantifying root resorption are digital reconstruction/subtraction using computer software^{10,11} linear measures of root length and root ratios³ and subjective evaluation using a scoring system.

Despite the global availability of evidence, there is limited information about how orthodontists in Pakistan diagnose, communicate, and manage EARR within routine practice. For this reason, a structured questionnaire was required to comprehensively capture all major domains of EARR management, including diagnosis, risk communication, treatment modification, and follow-up. However, developing such a tool was challenging as it needed to comprehensively cover all aspects of EARR. The Dutch Clinical Practice Guideline on EARR was identified as an ideal reference because it was systematically developed following a national survey in 2015 that highlighted the need for standardized recommendations. This led to the formation of a task force, which formulated key clinical questions and, in 2018 published the first evidence-based guideline that aligned with the internationally recognized AGREE II instrument providing recommendations on four main aspects of EARR which include diagnosis, risk factors, management, and follow up for EARR. This guideline covers each and every aspect of EARR; therefore this guideline was selected as the foundation for designing the questionnaire for Pakistani orthodontists.

Material and Methods

This was a cross-sectional questionnaire-based survey conducted to evaluate how Pakistani orthodontists address external apical root resorption (EARR) during treatment. The study was carried out in the Department of Orthodontics Saidu College of dentistry, Swat, Pakistan. The ethical approval The total study duration was three months (May–July 2025). Ethical approval for the study was obtained from the Ethical Review Committee of Saidu College of dentistry, Swat with ethical number **134-ERB/SMC/025**.

An online questionnaire was developed based on the clinical practice guideline prepared by the Dutch Association of Orthodontists. The questionnaire link was distributed to orthodontists in Pakistan. The minimum required sample size was estimated using G*Power 3.1

for detecting a medium effect (effect size = 0.3) with $\alpha = 0.05$ and power = 0.80 (van Doornik et al., 2024),¹² yielding a target of 89 respondents. A total of 101 complete responses were obtained via Google Forms and included in the final analysis. As participation was voluntary, the sample should be considered non-probability, and findings should be interpreted as descriptive and exploratory rather than population-representative. Consultant–resident subgroup analyses were interpreted descriptively, as no separate power calculation was performed for subgroup comparisons. The questionnaire was shared through social media platforms to the various orthodontic center housing consultant and resident orthodontists. A reminder was sent to those who had not completed the form after two months. The inclusion criteria for the study were consultants and resident orthodontists with relevant qualification and varying years of clinical experience. The exclusion criteria were general dentists and dental specialists from fields other than orthodontics (e.g., periodontics, prosthodontics, endodontics, pedodontics, oral surgery). The Ethical approvals were obtained from the institute before conducting the study. Every participant gave their informed consent and participation was completely voluntary. The questionnaire was created based on the CPG for EARR management by Dutch Association of Orthodontists during orthodontic treatment comprising two parts.

Part A included demographic questions about the respondents, such as sex, location of specialist education, years of clinical experience, and employment status.

Part B contained 13 questions covering the recommendations and four domains of the EARR guidelines, such as diagnosis, risk factors, treatment strategies, and follow-up care.

A small group of resident orthodontists tested the questionnaire to see how easy it was to understand, how clear it was, how well it was structured, and how long it took to fill out. After this, a group of orthodontists who had not been involved in the study before were asked over the final questionnaire to make sure it was valid and relevant. Respondents were requested to select an option between **1** and **7** depending on how likely they were to adhere to every guideline. **1** implied " Never " **2** implied " Very Rarely " **3** implied " Rarely " **4** implied " Neutral " **5** implied " Often " **6** implied "very often" and **7** implied "Always followed.

SPSS version 27 was used for data analysis. Questionnaire responses were recorded on a 7-point Likert - scale (1 = never to 7 = always). For descriptive purposes, Likert-scale responses were treated as approximately continuous variables and summarized using means, standard deviations, percentages, and frequencies. As the distribution of Likert-scale data could not be assumed to be normal, differences in responses between two groups were assessed using the Mann-Whitney U test as a conservative non-parametric alternative. For domain-level reporting,

item means were averaged and converted to a percentage of the maximum possible score to indicate overall domain adherence.

Results

The demographic outlines of the research population's showed at 37 (36.6%) participants out of of the 101 orthodontists were female and 64 (63.4%) were male. Seventy-two percent had fewer than five years of clinical experience. The majority (68.3%) worked in hospitals, followed by private practitioners (17.8%) and visiting orthodontists (13.9%) as shown in table 1.

Table 1. Demographic Characteristics of Participants (N = 101)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	64	63.4
	Female	37	36.6
Clinical experience	< 5 years	73	72.3
	> 5 years	28	27.7
Clinical practice	Hospital-based	69	68.3
	Private Practice	18	17.8
	Visiting Orthodontist	14	13.9

According to Table 2, the majority of responses were "Neutral" (34.7%) and "Often" (34.7%), suggesting case-based use rather than a regular strategy. Table 2 demonstrates that panoramic X-rays were used selectively at 12 months. On the other hand, the majority of orthodontists either answered "Very Often" (30.7%) or "Always" (23.7%), indicating that periapical imaging is the preferable technique when a thorough root examination is required

Findings from Table 3 reveal that orthodontists consistently communicate root resorption risks to their patients. The majority selected "Often" (43.6%) for

general risk and "Often" (42.6%) for extraction-related risk, suggesting strong awareness and patient education practices. Table 4 highlighted that most orthodontists preferred conservative strategies when managing root resorption. The majority reported frequently reviewing treatment goals (37.6%) and stopping force on affected teeth (40.6% "Very Often," 21.8% "Always"). Passive treatment breaks and limiting tooth movement were also commonly practiced, while discontinuation of treatment was reserved for more severe cases.

According to Table 5, most orthodontists routinely follow standard retention protocols, with 43.6% selecting "Often" and 14.9% "Very Often." Communication with patients about affected teeth was also prioritized, while coordination with general dentists was less consistent, indicating room for improved interdisciplinary collaboration.

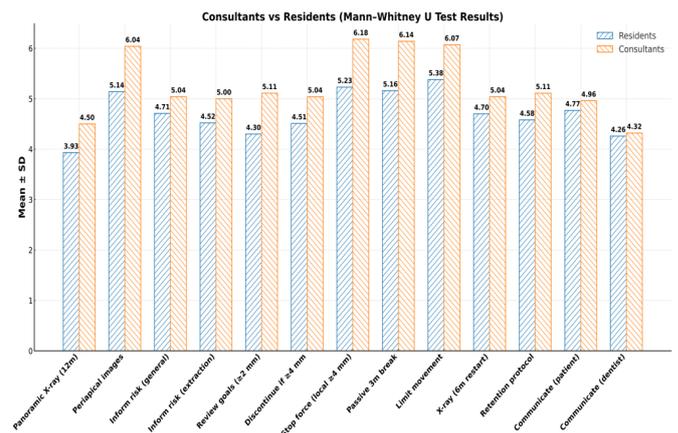


Figure 1: Results of the Mann–Whitney U test

Table 6 and Figure 1 show the results of the Mann–Whitney U test that consultants scored higher than residents in several aspects of diagnosis and treatment modification for external apical root resorption (EARR). Consultants tended to use panoramic and periapical X-rays more often, paid more attention to extraction risks, and preferred conservative strategies such as reviewing treatment goals, giving passive

Table :2 Root resorption diagnostic

Question	Never	Very rarely	Rarely	Neutral	Often	Very often	Always	Mean	SD
Panoramic X-ray (12 months)	5.9% (6)	5.0% (5)	12.9% (13)	34.7% (35)	34.7% (35)	5.9% (6)	0.9% (1)	4.09	1.24
Periapical Images (if insufficient info)	2.0% (2)	3.0% (3)	6.9% (7)	8.9% (9)	24.8% (25)	30.7% (31)	23.7% (24)	5.39	1.43

Table: 3 Awareness of risk factor

Question	Never	Very rarely	Rarely	Neutral	Often	Very often	Always	Mean	SD
Inform patient (general risk)	5.0% (5)	1.0% (1)	5.9% (6)	19.8% (20)	43.6% (44)	14.9% (15)	9.8% (10)	4.8	1.35
Inform patient (extraction risk)	3.0% (3)	5.0% (5)	9.9% (10)	16.8% (17)	42.6% (43)	16.8% (17)	5.9% (6)	4.65	1.33

Table 4 Management Strategies if EARR Detected During Treatment

Question	Never	Very rarely	Rarely	Neutral	Often	Very often	Always	Mean	SD
Review goals & discuss with patient (≥ 2 mm resorption)	5.0% (5)	5.9% (6)	5.9% (6)	26.7% (27)	37.6% (38)	8.9% (9)	9.9% (10)	4.52	1.45
Discontinue treatment (≥ 4 mm generalized resorption)	4.0% (4)	3.0% (3)	6.9% (7)	28.7% (29)	33.7% (34)	14.9% (15)	8.9% (9)	4.65	1.37
Stop forces on affected teeth (≥ 4 mm localized resorption)	5.0% (5)	2.0% (2)	3.0% (3)	3.0% (3)	24.8% (25)	40.6% (41)	21.8% (22)	5.5	1.47
Passive 3-month break before continuation	4.0% (4)	4.0% (4)	1.0% (1)	6.9% (7)	28.7% (29)	30.7% (31)	24.8% (25)	5.44	1.49
Limit movement of affected teeth	3.0% (3)	0.0% (0)	5.0% (5)	5.9% (6)	24.8% (25)	37.6% (38)	23.8% (24)	5.57	1.32
Take X-ray 6 months after restart	2.0% (2)	4.0% (4)	5.0% (5)	27.7% (28)	37.6% (38)	10.9% (11)	12.9% (13)	4.79	1.32

Table 5. Post-treatment Follow-Up Protocols

Question	Never	Very rarely	Rarely	Neutral	Often	Very often	Always	Mean	SD
Follow-up with patient per retention protocol	3.0% (3)	2.0% (2)	5.9% (6)	24.8% (25)	43.6% (44)	14.9% (15)	5.9% (6)	4.72	1.21
Communicate with patient about affected tooth at end of treatment	4.0% (4)	1.0% (1)	3.0% (3)	25.7% (26)	43.6% (44)	12.9% (13)	9.9% (10)	4.82	1.27
Communicate with the general dentist at end of treatment	5.0% (5)	4.0% (4)	13.9% (14)	30.7% (31)	32.7% (33)	6.9% (7)	5.9% (6)	4.28	1.36

Table 6. Mann–Whitney U Test Results (Consultants. vs Residents)

Section	Question	Resident Mean \pm SD	Consultant Mean \pm SD	U	p-value	Significant
Diagnosis	Panoramic X-ray at 12 months	3.93 \pm 1.24	4.50 \pm 1.17	691.0	0.0087	Yes
Diagnosis	Periapical images if insufficient info	5.14 \pm 1.39	6.04 \pm 1.40	592.0	0.0008	Yes
Risk Factors	Inform patient: general risk	4.71 \pm 1.45	5.04 \pm 1.07	855.0	0.1843	No
Risk Factors	Inform patient: extraction-related risk	4.52 \pm 1.40	5.00 \pm 1.12	772.5	0.0479	Yes
Treatment	Review goals & discuss (≥ 2 mm)	4.30 \pm 1.59	5.11 \pm 0.79	674.5	0.0062	Yes
Treatment	Discontinue if generalized ≥ 4 mm	4.51 \pm 1.47	5.04 \pm 0.96	832.0	0.1368	No
Treatment	Stop force on affected teeth (local ≥ 4 mm)	5.23 \pm 1.60	6.18 \pm 0.72	648.0	0.0029	Yes
Treatment	Passive 3-month break	5.16 \pm 1.56	6.14 \pm 1.01	610.0	0.0012	Yes
Treatment	Limit movement of affected teeth	5.38 \pm 1.39	6.07 \pm 0.98	712.5	0.0144	Yes
Treatment	X-ray 6 months after restart	4.70 \pm 1.39	5.04 \pm 1.10	840.0	0.1515	No
Follow-up	Retention protocol follow-up	4.58 \pm 1.32	5.11 \pm 0.74	781.5	0.0547	No
Follow-up	Communicate with patient (expectations)	4.77 \pm 1.43	4.96 \pm 0.69	952.5	0.5805	No
Follow-up	Communicate with general dentist	4.26 \pm 1.48	4.32 \pm 0.98	1030.5	0.861	No

breaks, stopping forces on affected teeth, and limiting tooth movement.

These data show that due to greater clinical experience and knowledge, consultants are more careful and have a preventive approach. In contrast, post treatment approaches were similar between consultants and residents, suggesting that communication and re-

tention protocols are applied consistently by all orthodontists. Figure 2 shows clearly higher scores for consultant compared to residents.

Discussion

This study evaluated the current practices of orthodontists in Pakistan regarding the diagnosis, commu-

nication, management, and follow-up of external apical root resorption (EARR), using the Dutch Clinical Practice Guideline as a framework. The results provide an overview of how practitioners in this region approach a well-recognized complication of orthodontic treatment and highlight both strengths and

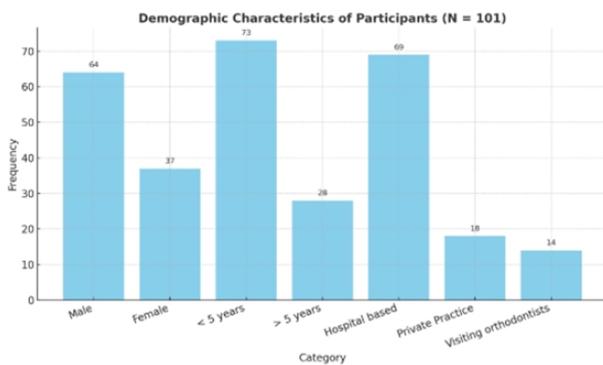


Figure 2 Demographic Data of Participants

areas where improvement is possible. Figure 2 shows the demographic data of participants.

Panoramic radiographs at 12 months were used selectively, with 34.7% of orthodontists responding “Neutral” and 34.7% “Often,” indicating that panoramic imaging is applied on a case-by-case basis rather than routinely. Conversely, periapical radiographs were used more consistently (30.7% “Very Often”, 23.7% “Always”), confirming their importance for detailed assessment. These findings align with recent literature showing that, according to Yi et al. 2017,¹⁰ cone beams computed tomography provides superior three-dimensional visualization and higher sensitivity for detecting and quantifying apical resorption compared with two-dimensional imaging. Stera G et al. 2024¹¹ also described that Periapical radiography offers higher spatial resolution than panoramic radiography, making it more suitable for detailed diagnostic evaluation. Similarly, Kaya et al. 2023¹³ and Benavides et al. 2024¹⁴ emphasize that cone-beam computed tomography is not a practical alternative to routine panoramic imaging in most clinical scenarios, largely due to higher radiation exposure, economic constraints, and ethical considerations, especially in younger patients. These findings together suggest that Pakistani orthodontists follow a practical, evidence-based diagnostic approach such as using periapical radiograph that mirrors global standards.

In this study, 43.6% of orthodontists reported “Often” informing patients about general root resorption risk, and 42.6% did so for extraction-related risk. This suggests that nearly two-thirds of respondents regularly communicate about potential complications, though communication is slightly lower in complex extraction cases, reflecting adherence to informed consent recommendations in contemporary guidance (Krishnan and Davidovitch 2021)¹⁵ If we look into international guidance (Sondeijker et al. 2020)³ they stress documenting known risk factors for EARR (for example, treatment duration, magni-

tude of force, tooth type, and history of trauma) and discussing these risks during informed consent. Inform all patients prior to initiating orthodontic treatment about the risk of EARR¹⁶. Another study by (Peker and Meriç 2024)¹⁷ and Wan et al. 2023)¹⁸ consisted of large cohort and imaging studies, also show that extraction treatment, longer treatment time and heavier forces are associated with greater degrees of EARR and should be part of the risk discussion with patients. The present study therefore reflects a growing awareness among Pakistani orthodontists of the ethical and clinical importance of informed consent in orthodontic care.

When EARR was detected, orthodontists predominantly adopted conservative approaches. The most frequent strategies included stopping force on affected teeth (40.6% “Very Often,” 21.8% “Always”), passive three-month treatment breaks (30.7% “Very Often,” 24.8% “Always”), and limiting tooth movement (37.6% “Very Often,” 23.8% “Always”). Only 33.7% reported “Often” discontinued treatment in generalized severe cases, showing preference for modification rather than cessation. (Sondeijker et al. 2020)³ described that the best approach is conservative measures such as reducing force magnitude, pausing active mechanics, or avoiding further movement of affected teeth are supported by clinical evidence and guideline panels as first-line strategies to arrest progression. (Yi et al. 2017)¹⁰ Clinical follow-up with standardized periapical radiographs after force modification is recommended to document arrest or progression before deciding on radical treatment discontinuation. Hence, Pakistani orthodontists’ practices closely follow modern evidence-based recommendations.

Follow-up care in this study showed strong patient focus: 43.6% “Often” and 14.9% “Very Often” followed standard retention protocols, while patient communication at the end of treatment was equally common (43.6% “Often”). However, collaboration with general dentists was reported less frequently (32.7% “Often”), revealing a need for stronger interdisciplinary communication. (Sondeijker et al. 2020)³ guidelines recommend clear documentation of EARR events, planned radiographic recall intervals and active handover to the patient’s general dentist for long-term surveillance after orthodontic treatment. (Pereira 2024)¹⁹ practical studies also suggest structured written communication (letter or checklist) to the restorative/general dentist improves detection of late progressing resorption and continuity of care. Findings from this study suggest that follow-up coordination between orthodontists and general practitioners which is limited in Pakistan may fail to detect late-stage resorption, and warn that professional coordination remains an area for improvement.

The comparison between consultants and residents revealed significant differences in diagnostic and treatment approaches toward external apical root resorption (EARR), as shown in Figure 1. Consultants

demonstrated higher adherence to evidence-based diagnostic protocols by using panoramic and periapical radiographs more frequently and by exhibiting greater awareness of extraction-related risks. Their preventive orientation was further evident in the preference for conservative measures such as reviewing treatment goals, implementing passive breaks, halting forces on affected teeth, and limiting tooth movement. Abutaleb et al.²⁰ similarly reported that senior orthodontists displayed better compliance with established EARR management guidelines, likely due to accumulated clinical judgment and familiarity with guideline-based protocols and improvement is required for residents especially for better patient outcome.

Interestingly, no significant differences were observed in post-treatment follow-up practices between these two groups. Both consultants and residents applied retention and patient communication protocols consistently. This suggests that in follow-up care, residents have a well-established routine aspect of practice, irrespective of experience level. It also indicates that postgraduate training programs are effective in the importance of long-term monitoring.

In summary, the results both inspire and suggest areas where practice could be improved. The consistent utilization of periapical radiographs, the preference for conservative treatment and the high consideration for patient communication are all factors that supplement reasons to believe in responsible clinical care. Meanwhile, selective application of the panoramic radiograph, less consistent dentist involvement and differing emphasis on extraction risks highlight areas where guidelines and continuing education could further reinforce practice.

This is the first study to investigate EARR management practices among orthodontists in Pakistan using a validated international guideline as a reference. By highlighting both common practices and consultant-resident differences, it contributes to an understanding

of regional practice patterns and provides a baseline for developing localized recommendations.

Limitation

This study has some limitations, which include the use of a self-reported questionnaire based on CPG guidelines, which may be subjected to recall bias. Another limitation includes convenience sampling, which may not fully represent all orthodontists in Pakistan. The study relied on reported practices rather than direct observation as actual behavior may vary in clinical settings. A longitudinal study could provide deeper insight into real-world practices and outcomes.

Conclusion

Orthodontists in Pakistan show a patient beneficial and cautious approach for managing complication such as external apical root resorption (EARR). Diagnostic practices favor periapical imaging for comprehensive evaluation to monitor EARR. Risk communication with patients is regularly performed. In case of root resorption is detected, conservative treatment adjustments are preferred over discontinuation. Consultants tend to adopt more preventive measures than residents, reflecting the influence of experience and knowledge, while post treatment follow up practices are consistent across groups. These findings highlight strengths in diagnostic awareness, patient risk factor communication and treatment strategies while pointing to the need for stronger collaboration with patients and general dentists about retention and EARR to improve continuity of care. Awareness of EARR is the need of time especially in resident orthodontists in Pakistan because they lag behind consultants in several aspect of EARR management.

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References

1. Yassir YA, McIntyre GT, Bearn DR. Orthodontic treatment and root resorption: an overview of systematic reviews. *European journal of orthodontics*. 2021 Aug 1;43(4):442-56.
2. Sameshima GT, Iglesias-Linares A. Orthodontic root resorption. *J World Fed Orthod*. 2021 Dec;10(4):135-143.
3. Sondejker CF, Lamberts AA, Beckmann SH, Kuitert RB, Van Westing K, Persoon S, Kuijpers-Jagtman AM. Development of a clinical practice guideline for orthodontically induced external apical root resorption. *European journal of orthodontics*. 2020 Apr 1;42(2):115-24.
4. Weltman B, Vig KW, Fields HW, Shanker S, Kaizar EE. Root resorption associated with orthodontic tooth movement: a systematic review. *American journal of orthodontics and dentofacial orthopedics*. 2010 Apr 1;137(4):462-76.
5. Chan EK, Darendeliler MA. Exploring the third dimension in root resorption. *Orthodontics & craniofacial research*. 2004 May;7(2):64-70.
6. Dos Santos CC, Bellini-Pereira SA, Medina MC, Normando D. Allergies/asthma and root resorption: a systematic review. *Progress in orthodontics*. 2021 Mar 15;22(1):8.
7. Yassir YA, El-Angbawi AM, McIntyre GT, Revie GF, Bearn DR. A randomized clinical trial of the effectiveness of 0.018-inch and 0.022-inch slot orthodontic bracket systems: part 1-duration of treatment. *Eur J Orthod*. 2019 Mar 29;41(2):133-142.

8. Darendeliler MA, Kharbanda OP, Chan EK, Srivicharnkul P, Rex T, Swain MV, Jones AS, Petocz P. Root resorption and its association with alterations in physical properties, mineral contents and resorption craters in human premolars following application of light and heavy controlled orthodontic forces. *Orthodontics & craniofacial research*. 2004 May;7(2):79-97.
9. Ponder SN, Benavides E, Kapila S, Hatch NE. Quantification of external root resorption by low-vs high-resolution cone-beam computed tomography and periapical radiography: a volumetric and linear analysis. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2013 Jan 1;143(1):77-91.
10. Yi J, Sun Y, Li Y, Li C, Li X, Zhao Z. Cone-beam computed tomography versus periapical radiograph for diagnosing external root resorption: a systematic review and meta-analysis. *The Angle Orthodontist*. 2017 Mar 1;87(2):328-37.
11. Stera G, Giusti M, Magnini A, Calistri L, Izzetti R, Nardi C. Diagnostic accuracy of periapical radiography and panoramic radiography in the detection of apical periodontitis: a systematic review and meta-analysis. *La radiologia medica*. 2024 Nov;129(11):1682-95.
12. van Doornik SP, Pijnenburg MB, Janssen KI, Ren Y, Kuijpers-Jagtman AM. Evaluation of the use of a clinical practice guideline for external apical root resorption among orthodontists. *Progress in Orthodontics*. 2024 Apr 22;25(1):15.
13. Kaya B, Gülşahı A, Türkyılmaz G. Factors that may increase the risk of external apical root resorption during orthodontic treatment: Retrospective clinical investigation. *Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopädie*. 2024 Nov;85(6):425-34.
14. Benavides E, Krecioch JR, Connolly RT, Allareddy T, Buchanan A, Spelic D, O'Brien KK, Keels MA, Mascarenhas AK, Duong ML, Aerne-Bowe MJ. Optimizing radiation safety in dentistry: clinical recommendations and regulatory considerations. *The Journal of the American Dental Association*. 2024 Apr 1;155(4):280-93.
15. Krishnan V, Davidovitch ZE, Ramachandran R. Planning and Executing Tooth-movement Research. *Biological Mechanisms of Tooth Movement*. 2021 Apr 9:309-26
16. Kuijpers MA, van Doornik SP, Kuijpers-Jagtman AM. Orthodontically induced external apical root resorption and demineralized lesions: Clinical considerations in orthodontic finishing. In *Seminars in Orthodontics 2025* Oct 17. WB Saunders.
17. Peker RB, Meriç P. Evaluation of External Apical Root Resorption in Cases with Extraction and Non-Extraction Fixed Orthodontic Treatment. *Diagnostics*. 2024 Oct 21;14(20):2338.
18. Wan J, Zhou S, Wang J, Zhang R. Three-dimensional analysis of root changes after orthodontic treatment for patients at different stages of root development. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2023 Jan 1;163(1):60-7.
19. Pereira SA, Corte-Real A, Melo A, Magalhães L, Lavado N, Santos JM. Diagnostic accuracy of cone beam computed tomography and periapical radiography for detecting apical root resorption in retention phase of orthodontic patients: a cross-sectional study. *Journal of Clinical Medicine*. 2024 Feb 22;13(5):1248.
20. Abutaleb MA, Latief MH, Montasser MA. Reflection on patients' experience with orthodontic appliances wear and its impact on oral health related quality of life: observational comparative study. *BMC Oral Health*. 2023 Jul 19;23(1):502.

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Author Contributions

1. **Samia Rahman** : Conceptualization of the study, study design, and manuscript drafting.
2. **Haroon ur Rashid**: Data collection and coordination with participating orthodontists.
3. **Sajid Ali**: Data analysis and interpretation of results.
4. **Ali Hassan Qureshi**: Literature review and assistance in manuscript preparation.
5. **Naser Hussain Khan**: Critical revision of the manuscript and subject-matter expertise.
6. **Waqar Ali Khan**: Study supervision and final approval of the version to be published.