Scholars Journal of Dental Sciences
Abbreviated Key Title: Sch J Dent Sci
ISSN 2394-4951 (Print) | ISSN 2394-496X (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Comparison of the Rate of Maxillary Canine Retraction with Conventional Molar Anchorage and Titanium Mini-Implant Anchorage: A Split-Mouth Quasi-Experimental Study

Rokeya Rahman Tani[1*], Mohsin Munir Khan Nabil[2], Mst Farzana Yeasmin[3], Shamsia Noshin[4], Mehreen Zakir[5]

[1]Chief Consultant (Orthodontist), Dr. TANI Orthodontic Centre, Dhaka, Bangladesh
[2]Assistant Professor, Department. of Oral and Maxillofacial Surgery, Kumudini Women's Medical College & Hospital, Dental Unit, Mirzapur, Tangail, Bangladesh
[3]Consultant (Orthodontics & Dentofacial Orthopedics), BRB Hospital, Dhaka, Bangladesh
[4]Assistant Professor, Dept. of Orthodontics & Dentofacial Orthopedics, Kumudini Women's Medical College & Hospital, Dental Unit, Mirzapur, Tangail, Bangladesh
[5]Consultant Orthodontist, Ortho Dental Care, Dhaka, Bangladesh

DOI: https://doi.org/10.36347/sjds.2026.v13i09.001 | **Received:** 17.08.2026 | **Accepted:** 01.09.2026 | **Published:** 08.09.2026

***Corresponding author**: Dr. Rokeya Rahman Tani
Chief Consultant (Orthodontist), Dr. TANI Orthodontic Centre, Dhaka, Bangladesh, e-mail: tanirahman71@gmail.com

Abstract **Original Research Article**

Background: Anchorage control is critical during maxillary canine retraction in premolar-extraction orthodontic cases. Titanium mini-implants offer absolute intraoral anchorage and may shorten treatment duration compared with conventional molar anchorage; however, comparative data from Bangladeshi patients are lacking. ***Objective:*** To measure and compare the amount, duration and rate of maxillary canine retraction between titanium mini-implant anchorage and conventional molar anchorage using a split-mouth design. ***Materials and Methods*:** A quasi-experimental split-mouth study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, Dhaka Dental College & Hospital, Dhaka, Bangladesh, over a six-month period. Sixteen patients requiring therapeutic extraction of both maxillary first premolars and maximum anchorage were enrolled by convenience sampling. After levelling and alignment with a 0.018-inch slot pre-adjusted edgewise appliance (Roth prescription), a Vector TAS titanium mini-implant (1.4 × 8 mm; Ormco, Germany) was inserted between the second premolar and first molar on the right side of the maxilla; the contralateral side received conventional molar anchorage with a banded first molar. Canine retraction was carried out on a 0.016-inch stainless-steel arch wire using NiTi closed-coil springs (Ormco) delivering 150 g of force, measured with a Correx/Dontrix gauge. Pre- and post-retraction lateral cephalograms with customized wire guides were used to measure the horizontal distance from a sella–nasion vertical reference line to the canine hook. The amount of canine retraction was the difference between the two measurements, and the rate was obtained by dividing this amount by the time required for retraction. Data were analyzed and compared by statistical change. ***Results:*** A total of 16 patients were enrolled (4 male, 12 females; aged 15–25 years; mean age 19.1 ± 3.7 years). The mean amount of canine retraction was 7.94 ± 2.17 mm on the implant side and 7.13 ± 2.39 mm on the conventional molar side ($p = 0.323$). The mean duration of retraction was 5.80 ± 1.66 months and 6.17 ± 2.00 months, respectively ($p = 0.565$). The mean rate of canine retraction was 1.37 ± 0.40 mm/month on the implant side and 1.25 ± 0.43 mm/month on the molar side ($p = 0.395$). No significant differences were detected between age groups or between the sexes ($p>0.05$). ***Conclusion:*** Within the limitations of this small split-mouth study, titanium mini-implant anchorage produced a slightly faster rate of maxillary canine retraction than conventional molar anchorage, but the difference was not statistically significant. Mini-implants nonetheless provide a reliable, compliance-independent absolute anchorage option for maximum-anchorage cases.
Keywords: Canine retraction; Mini-implant; Temporary anchorage device; Molar anchorage; Split-mouth study.

1. INTRODUCTION

The principal goal of orthodontic treatment is to achieve the desired tooth movement with minimal undesired side effects. Anchorage defined as resistance to unwanted tooth movement is one of the most critical considerations in orthodontic biomechanics [1]. When planning treatment, the clinician must consider not only the forces required to move the target teeth but also the reciprocal forces acting on the anchor unit [2].

The rate of tooth movement directly influences treatment duration; a sound understanding of canine retraction rates is therefore essential for efficient treatment planning [3]. In extraction cases, retraction of the canines into the first-premolar extraction space is one of the commonest procedures, and the canine occupies a strategic position linking the anterior and posterior segments. Historically, anchorage has been reinforced using molar bands, transpalatal arches, soldered power arms on the first or second molars, headgear, or other adjuncts [4]. Reported rates of canine retraction with conventional methods vary widely, ranging from approximately 0.35 to 1.55 mm/month depending on appliance design, force magnitude, individual biology and measurement technique [5-11].

In recent decades, orthodontic mini-implants—also known as temporary anchorage devices (TADs)—have emerged as a reliable alternative source of intraoral anchorage. They provide absolute anchorage that does not depend on patient compliance and may be used when teeth are unavailable as anchor units, when extraoral appliances are impractical or as an alternative to orthognathic surgery [12]. Orthodontic implants have been placed in the alveolar bone [13], the retromolar region [14], the midpalatal region [15] and the lingual [16] and buccal [17] cortical plates. A meta-analysis demonstrated that mini-implant anchorage retracts the anterior teeth more effectively than traditional anchorage [18]. Mini-implants can shorten treatment time by allowing efficient distalisation of the canines with minimal anchorage loss [19] and have an overall high success rate [20] without requiring patient compliance [21].

In Bangladesh, a small number of case reports have addressed canine retraction with conventional anchorage in bimaxillary protrusion [22], Class I crowding [23] and Class II Division 1 malocclusion [24]. However, no clinical trial or case series yet evaluated mini-implant anchorage in a Bangladeshi orthodontic population. The present study was therefore designed to compare the rate of maxillary canine retraction between conventional molar anchorage and titanium mini-implant anchorage on the contralateral side within the same patient.

2. MATERIALS AND METHODS

2.1 Study design and setting

This was a quasi-experimental, split-mouth study conducted in the Department of Orthodontics and Dentofacial Orthopedics, Dhaka Dental College & Hospital, Dhaka, Bangladesh, over a six-month period following protocol approval. A split-mouth design was selected so that direct intra-individual comparisons could be made between the implant-anchored and molar-anchored sides while controlling for patient-specific factors. The right side of the maxilla received mini-implant anchorage and the left side received conventional molar anchorage.

2.2 Ethical approval

Ethical clearance was obtained from the Institutional Ethical Review Committee of Dhaka Dental College & Hospital. Written informed consent was obtained from every participant after a verbal explanation of the nature, purpose, benefits and potential risks of the study. Participants were free to withdraw at any stage without penalty. Patient identity and clinical data were kept strictly confidential.

2.3 Participants

Sixteen young patients attending the outpatient clinic and requiring therapeutic extraction of both maxillary first premolars and maximum anchorage were recruited consecutively by convenience sampling.

Inclusion criteria: patients aged between 15-25 years; indicated therapeutic extraction of both maxillary first premolars; completed levelling and alignment phase; need for maximum anchorage.

Exclusion criteria: patients having history of systemic illness; missing, impacted or significantly malformed teeth anterior to the first molar; previous orthodontic treatment; any pathological oral lesion (cyst, tumour, bony lesion); compromised periodontium; known titanium allergy; inability or unwillingness to provide written informed consent.

2.4 Appliance and intervention

All patients were treated with a 0.018-inch slot pre-adjusted edgewise appliance (Roth prescription). After levelling and alignment, a 0.016-inch stainless-steel arch wire was placed and bilateral therapeutic extraction of the maxillary first premolars was performed; the patient was reviewed after one week. A pre-retraction lateral cephalogram and a stent-guided periapical radiograph were obtained for implant-site assessment.

Under aseptic precautions, oral antisepsis with povidone-iodine mouth-wash and local infiltration anaesthesia, a Vector TAS titanium mini-implant (1.4 × 8 mm; Ormco, Germany) was inserted between the roots of the maxillary right second premolar and first molar at the maximum interradicular bone thickness, using a self-drilling hand driver. The implant was angled at 30°–40° to the long axis of the adjacent teeth to maximise cortical contact and primary stability. On the left (control) side, a band was placed on the first molar (Figure 1).

Figure 1: Vector TAS titanium mini-implant (1.4 × 8 mm; Ormco, Germany) loading onto the self-drilling hand driver prior to insertion

Canine retraction was initiated immediately after mini-implant placement. A NiTi closed-coil spring (Ormco, Germany) delivering 150 g of force verified with a Correx/Dontrix pressure-tension gauge (Dentaurum, Germany) was stretched between the mini-implant head and the canine hook on the implant side, and between the molar band hook and the canine hook on the molar side. Clinical evaluation was performed every three weeks. Springs were reactivated as needed to maintain the prescribed force (Figure 2a, 2b).

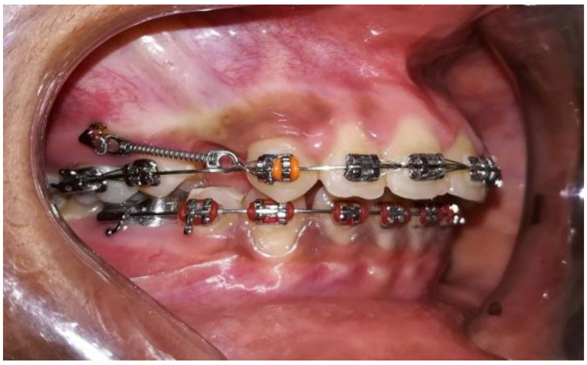

Figure 2a: Implant-anchored side: NiTi closed-coil spring extended between the titanium mini-implant and the maxillary canine for distal retraction

Figure 2b: Conventional molar-anchored side: NiTi closed-coil spring extended between the banded first molar and the maxillary canine

2.5 Outcome measurements

The primary outcomes were the amount, duration and rate of maxillary canine retraction on each side. Two sets of records were obtained: pre-retraction (after first-premolar extraction and immediately after mini-implant placement) and post-retraction (after closure of the extraction space). The principal record was the lateral cephalogram. Customized guides constructed from 0.016 × 0.022-inch stainless-steel wire were inserted into the molar buccal tubes and the canine bracket hooks before each cephalogram to differentiate the right and left sides on the radiograph.

On the lateral cephalogram, a vertical reference line (SN-vertical) was drawn from the sella–nasion (SN) plane through the sella (S) point. The horizontal distance from this reference line to the wire guide on the canine bracket hook was measured on both sides at the pre-retraction and post-retraction time-points. The amount of canine retraction was calculated as the difference between the two measurements, and the rate of retraction as the amount divided by the time taken (mm/month). Cephalometric tracings were performed manually on A4 acetate paper using a sharp pencil and millimeter rule (Figure 3).

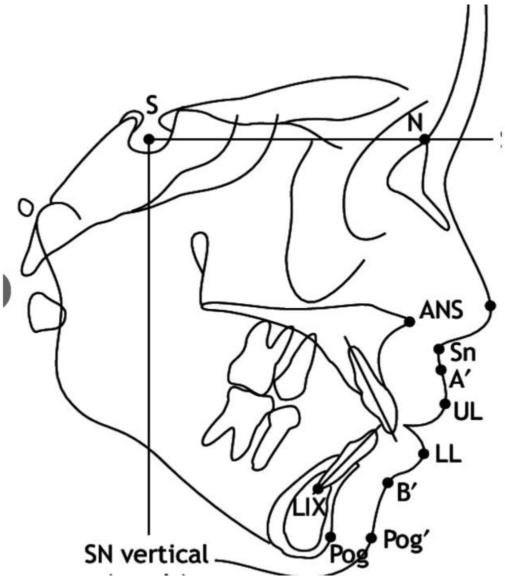

Figure 3: Cephalometric tracing showing the sella (S) and nasion (N) landmarks and the SN-vertical reference line used to measure the horizontal displacement of the canine.

2.6 Statistical analysis

Data were entered, cleaned and analyzed using Windows-based software Statistical Package for Social Sciences (SPSS) version 26. Continuous variables are presented as mean ± standard deviation (SD) with ranges; categorical variables as frequencies and percentages. Independent-samples (unpaired) Student's t-tests were used to compare the implant and molar sides and to compare age and sex subgroups. A p-value of ≤ 0.05 was considered statistically significant.

3. RESULTS

Sixteen patients completed the study. The mean age was 19.1 ± 3.7 years (range 15-25 years); 9 patients (56.3%) were aged 15-20 years and 7 (43.8%) were aged 21-25 years. Twelve participants (75.0%) were female and 4 (25.0%) were male, giving a male-to-female ratio of approximately 1:3. Most patients were students (87.5%); the remainder were teachers (12.5%). Demographic characteristics are summarized in Table 1.

Table 1: Demographic profile of the study patients (N = 16)

Variable	Category	Number of patients	Percentage (%)
Age (years)	15–20	9	56.3
	21–25	7	43.8
Sex	Male	4	25.0
	Female	12	75.0
Occupation	Student	14	87.5
	Teacher	2	12.5

The mean amount of canine retraction on the implant-anchored side was 7.94 ± 2.17 mm (range 5.0-13.0 mm) compared with 7.13 ± 2.39 mm (range 4.0-12.0 mm) on the conventional molar-anchored side. The difference was not statistically significant ($t = 1.006$; $p = 0.323$) (Table 2).

Table 2: Amount of maxillary canine retraction (mm) on implant- and molar-anchored sides (N = 16)

Group	n	Mean	SD	Range (min-max)	t-value	p-value
Implant	16	7.94	2.17	5.0-13.0	1.006	0.323
Conventional molar	16	7.13	2.39	4.0-12.0		

The mean duration of canine retraction was 5.80 ± 1.66 months (range 3.23-8.60) on the implant side and 6.17 ± 2.00 months (range 3.23-9.16) on the molar side (t = 0.581; p = 0.565), with no statistically significant difference (Table 3).

Table 3: Duration of maxillary canine retraction (months) on implant- and molar-anchored sides (N = 16)

Group	n	Mean	SD	Range (min–max)	t-value	p-value
Implant	16	5.80	1.66	3.23-8.60	0.581	0.565
Conventional molar	16	6.17	2.00	3.23-9.16		

The mean rate of maxillary canine retraction was 1.37 ± 0.40 mm/month (range 0.64-2.18) on the implant side and 1.25 ± 0.43 mm/month (range 0.51-2.20) on the conventional molar side. Although the rate was numerically faster on the implant-anchored side, the difference was not statistically significant (t = 0.863; p = 0.395) (Table 4).

Table 4: Rate of maxillary canine retraction (mm/month) on implant- and molar-anchored sides (N = 16)

Group	n	Mean	SD	Range (min–max)	t-value	p-value
Implant	16	1.37	0.40	0.64-2.18	0.863	0.395
Conventional molar	16	1.25	0.43	0.51-2.20		

Comparison of the amount, duration and rate of canine retraction between the two age subgroups (15-20 years vs 21-25 years) and between male and female patients showed no statistically significant differences (all p>0.05) (Table 5). However, the difference in retraction rate between age groups approached significance (1.43 ± 0.37 mm/month in the 15-20-years group vs 1.16 ± 0.42 mm/month in the 21-25-years group; p = 0.067), suggesting a possible trend towards faster retraction in younger patients.

Table 5: Comparison of canine retraction by age group and by sex (N = 16)

Variable	Subgroup	n	Mean	SD	t-value	p-value
Amount (mm)	15-20 years	9	7.78	2.32	0.686	0.498
	21-25 years	7	7.21	2.29		
Duration (months)	15-20 years	9	5.51	1.41	1.644	0.106
	21-25 years	7	6.60	2.13		
Rate (mm/month)	15-20 years	9	1.43	0.37	1.904	0.067
	21-25 years	7	1.16	0.42		
Amount (mm)	Male	4	8.50	2.73	1.406	0.170
	Female	12	7.21	2.08		
Duration (months)	Male	4	5.96	2.03	0.038	0.970
	Female	12	5.99	1.78		
Rate (mm/month)	Male	4	1.47	0.59	1.233	0.227
	Female	12	1.26	0.33		

4. DISCUSSION

Orthodontic research has long focused on making tooth movement faster, more controlled and biologically safer. Canine retraction into the first-premolar extraction space is one of the most frequently performed procedures, and the choice of anchorage modality directly influences both the rate of retraction and the amount of anchorage loss. The present quasi-experimental split-mouth study compared titanium mini-implant anchorage with conventional molar anchorage within the same patient, using a stable cranial landmark (the sella point with an SN-vertical reference line) for cephalometric measurement, in contrast to earlier studies that have sometimes used unstable dental landmarks such as the mesio-incisal angle of the upper central incisor.

The mean rate of canine retraction in the present study was 1.37 ± 0.40 mm/month on the implant side and 1.25 ± 0.43 mm/month on the molar side. These values fall within the wide range reported in the literature (0.35-1.55 mm/month) [5-11]. Paulsen et al., [5] and Sleichter [10] reported approximately 1 mm/month with conventional mechanics, consistent with our findings on the molar-anchored side. Sonis et al., [6] recorded retraction of 0.99-1.51 mm over a 3-week period, while Dixon et al., [7] documented 0.81 mm/month with NiTi coil springs in a randomized clinical trial; Darendeliler et al., [8] reported 0.87 mm/month with pull-coil springs. Boester and Johnston [9] obtained higher rates of 3.24 mm (maxilla) and 2.05 mm (mandible) over 2 months, almost certainly because of the higher force levels they applied. Hixon et al., [11] reported 0.17 mm/week with a 100 g force. The variability between studies is attributable to differences in force magnitude, appliance type, sample characteristics and measurement technique.

The numerically faster retraction on the implant-anchored side in our study mirrors trends reported by other split-mouth investigations. Davis et al., [31] reported mean rates of 0.95 and 0.82 mm/month on the implant and molar sides of the maxilla, respectively. Thiruvenkatachari et al., [26] documented rates of 0.93 mm/month (implant) and 0.81 mm/month (molar) in the maxilla, concluding that titanium mini-implants are simple and efficient anchors when maximum anchorage is required. Joshi et al., [33] reported en-masse retraction rates of 0.77 and 0.69 mm/month for mini-implant and conventional power-arm anchorage, respectively. The absolute values obtained in the present study are slightly higher than those of these earlier reports, possibly reflecting differences in arch-wire size, force calibration, biological response and the use of single-canine retraction rather than en-masse retraction in our protocol.

The mean amount of canine retraction was 7.94 ± 2.17 mm on the implant side and 7.13 ± 2.39 mm on the molar side. Thiruvenkatachari et al., [26] reported smaller amounts (4.29 ± 0.45 mm and 3.79 ± 0.45 mm on implant and molar sides, respectively), and Davis *et al.,*[31] reported 4.40 ± 0.46 mm and 4.20 ± 0.58 mm. The larger amount of canine retraction recorded in our study probably reflects greater initial extraction-space requirements and longer total retraction periods. Although there was no statistically significant difference between sides, the implant side consistently showed a slightly greater amount and faster rate of canine retraction with less mesial molar drift, supporting the biomechanical rationale that mini-implants act as a stationary anchor unit. Minaz and Amin [34] reported a mean molar anchorage loss of only 0.17 ± 0.30 mm on the mini-implant side, while Upadhyay et al., [39] and Becker et al., [40] have also shown markedly less anchorage loss with mini-implants compared with conventional mechanics. Tawfik et al., [32] likewise reported no statistically significant difference in canine-retraction rate between two different mechanics, in line with our finding.

Comparisons by age and sex did not yield statistically significant differences, in keeping with the literature. A trend ($p = 0.067$) towards faster retraction in patients aged 15-20 years compared with 21–25 years is biologically plausible, given the more responsive periodontal-ligament remodelling capacity in younger individuals, but the small subgroup size precludes firm conclusions. The split-mouth design was a methodological strength: by studying both anchorage modalities in the same patient, individual variation in periodontal-ligament biology, force tolerance, oral-hygiene status and compliance is largely controlled for, and the two sides can reasonably be treated as independent observations.

Within the bounds of the study, mini-implants performed at least as well as conventional molar anchorage in terms of canine-retraction rate while offering the well-documented advantages of compliance-independent absolute anchorage and reduced mesial molar movement. In recent years, the introduction of orthodontic mini-implants has expanded the boundaries of tooth movement possible with fixed appliances and represents the only routinely available method of absolute intraoral anchorage.

5. CONCLUSION

Within the limitations of this split-mouth quasi-experimental study, no statistically significant difference was observed in the amount, duration or rate of maxillary canine retraction between titanium mini-implant anchorage and conventional molar anchorage. The numerical trend favoured the mini-implant side (1.37 ± 0.40 mm/month vs 1.25 ± 0.43 mm/month). Age and sex did not significantly influence the outcomes. Titanium mini-implants therefore provide a clinically reliable, compliance-independent option for maximum anchorage during maxillary canine retraction and warrant further evaluation in larger studies.

Limitations of the study

It was a single center study with a relatively small sample size which reduces statistical power and limits the generalizability of the findings. Non-probability (convenience) sampling was used because of the limited number of patients meeting the strict inclusion criteria during the study window. The line of force application differed slightly between the mini-implant and molar sides, which may have introduced minor biomechanical confounding. Moreover, manual cephalometric tracing on acetate paper is subject to a small but unavoidable measurement error; intra-examiner reliability was not formally assessed.

Recommendations

Larger multi-center studies with longer follow-up and matched malocclusion types are needed to confirm these findings. Force vectors should ideally be standardized between mini-implant and molar sides in future split-mouth studies. Future research should include anchorage loss, bone density and implant site.

Conflicts of interest

All authors declare that there is no conflict of interest regarding this publication.

REFERENCES

1. Proffit WR, Fields HW Jr. Contemporary Orthodontics. 3rd ed. St. Louis: Mosby Inc.; 2000.
2. Nanda R. Biomechanics and Esthetic Strategies in Clinical Orthodontics. 1st ed. St. Louis: Elsevier Inc.; 2005.

3. Mavreas D, Athanasiou AE. Factors affecting the duration of orthodontic treatment: a systematic review. Eur J Orthod. 2008;30(4):386–95.
4. Shivanand V, Rozario JE, Sangamesh B, Patil AK, Ganeshkar SV. Bonding power arms to standard molar tubes. J Clin Orthod. 2012;46(3):172–4.
5. Paulsen RC, Speidel TM, Isaacson RJ. A laminagraphic study of cuspid retraction versus molar anchorage loss. Angle Orthod. 1970;40(1):20–7.
6. Sonis AL, Van der Plas E, Gianelly A. A comparison of elastomeric auxiliaries versus elastic thread on premolar extraction site closure: an in vivo study. Am J Orthod. 1986;89(1):73–8.
7. Dixon V, Read MJ, O'Brien KD, Worthington HV, Mandall NA. A randomized clinical trial to compare three methods of orthodontic space closure. J Orthod. 2002;29(1):31–6.
8. Darendeliler MA, Darendeliler H, Üner O. The drum spring (DS) retractor: a constant and continuous force for canine retraction. Eur J Orthod. 1997;19(2):115–30.
9. Boester CH, Johnston LE. A clinical investigation of the concepts of differential and optimal force in canine retraction. Angle Orthod. 1974;44(2):113–9.
10. Sleichter CG. A clinical assessment of light and heavy forces in the closure of extraction spaces. Angle Orthod. 1971;41(1):66–75.
11. Hixon EH, Atikian H, Callow GE, McDonald HW, Tacy RJ. Optimal force, differential force, and anchorage. Am J Orthod. 1969;55(5):437–57.
12. Melsen B. Mini-implants: where are we? J Clin Orthod. 2005;39(9):539–47.
13. Ödman J, Lekholm U, Jemt T, Thilander B. Osseointegrated implants as orthodontic anchorage in the treatment of partially edentulous adult patients. Eur J Orthod. 1994;16(3):187–201.
14. Roberts WE, Marshall KJ, Mozsary PG. Rigid endosseous implant utilized as anchorage to protract molars and close an atrophic extraction site. Angle Orthod. 1990;60(2):135–52.
15. Block MS, Hoffman DR. A new device for absolute anchorage for orthodontics. Am J Orthod Dentofacial Orthop. 1995;107(3):251–8.
16. Lee JS, Park HS, Kyung HM. Micro-implant anchorage for lingual treatment of a skeletal Class II malocclusion. J Clin Orthod. 2001;35(10):643–7.
17. Kyung HM, Park HS, Bae SM, Sung JH, Kim IB. Development of orthodontic micro-implants for intraoral anchorage. J Clin Orthod. 2003;37(6):321–8.
18. Xu Y, Xie J. Comparison of the effects of mini-implant and traditional anchorage on patients with maxillary dentoalveolar protrusion: a systematic review. Angle Orthod. 2017;87(2):320–7.
19. Thiruvenkatachari B, Pavithranand A, Rajasigamani K, Kyung HM. Comparison and measurement of the amount of anchorage loss of the molars with and without the use of implant anchorage during canine retraction. Am J Orthod Dentofacial Orthop. 2006;129(4):551–4.
20. Maino BG, Pagin P, Di Blasio A. Success of miniscrews used as anchorage for orthodontic treatment: analysis of different factors. Prog Orthod. 2012;13(3):202–9.
21. Chang HP, Tseng YC. Miniscrew implant applications in contemporary orthodontics. Kaohsiung J Med Sci. 2014;30(3):111–5.
22. Mamun MSA, Hossain MZ. Management of bimaxillary protrusion – a case report. Bangladesh J Orthod Dentofac Orthop. 2013;3(2):32–4.
23. Mahmud AMS, Taher MA, Hossain MZ. Orthodontic management of Class I crowding in an adult male – a case report. Bangladesh J Orthod Dentofac Orthop. 2012;3(1):34–7.
24. Ali MW, Hossain MZ. Successful orthodontic treatment of Class II Division 1 malocclusion in a non-growing patient – a case report. Bangladesh J Orthod Dentofac Orthop. 2012;2(2):41–5.
25. Park HS, Bae SM, Kyung HM, Sung JH. Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. J Clin Orthod. 2001;35(7):417–22.
26. Thiruvenkatachari B, Ammayappan P, Kandaswamy R. Comparison of rate of canine retraction with conventional molar anchorage and titanium implant anchorage. Am J Orthod Dentofacial Orthop. 2008;134(1):30–5.
27. Iwasaki LR, Haack JE, Nickel JC, Morton J. Human tooth movement in response to continuous stress of low magnitude. Am J Orthod Dentofacial Orthop. 2000;117(2):175–83.
28. Ricketts RM. Development of retraction sections. Found Orthod Res Newsl. 1974;5:41–4.
29. Lee BW. Relationship between tooth-movement rate and estimated pressure applied. J Dent Res. 1965;44(5):1053–5.
30. Paulson RC, Speidel TM, Isaacson RJ. A laminagraphic study of cuspid retraction versus molar anchorage loss. Angle Orthod. 1970;40(1):20–7.
31. Davis D, Krishnaraj R, Duraisamy S, Ravi K, Dilip S, Charles A, *et al.,*Comparison of rate of canine retraction and anchorage potential between mini-implant and conventional molar anchorage: an in vivo study. Contemp Clin Dent. 2018;9(3):337–42.
32. Tawfik MA, Abouelnour AM, El Bedwehi AA. Maxillary canine retraction rate using two different orthodontic mechanics (a prospective clinical study). Al-Azhar J Dent Sci. 2021;24(1):93–100.
33. Joshi HN, Goje SK, Kulkarni N, Shah R, Chellani S, Soni J, *et al.,*Evaluation of angular changes of canine in en-masse retraction of maxillary anterior teeth using power arm and titanium mini-implant – a split-mouth randomised control study. J Evol Med Dent Sci. 2021;10(8):522–7.
34. Minaz, Amin V. Comparison and measurement of molar anchorage loss during en-masse retraction

using mini-implant and conventional mechanics. Saudi J Oral Dent Res. 2022;7(9):213–9.
35. Felemban NH, Al-Sulaimani FF, Murshid ZA, Hassan AH. En-masse retraction versus two-step retraction of anterior teeth in extraction treatment of bimaxillary protrusion. J Orthod Sci. 2013;2(1):28–37.
36. Braun S, Sjursen RC Jr, Legan HL. On the management of extraction sites. Am J Orthod Dentofacial Orthop. 1997;112(6):645–55.
37. Londhe SM, Kumar P, Mitra R, Kotwal A. Efficacy of second molar to achieve anchorage control in maximum anchorage cases. Med J Armed Forces India. 2010;66(3):220–4.
38. Consolaro A, Romano FL. Reasons for mini-implant failure: choosing installation site should be valued! Dental Press J Orthod. 2014;19(2):18–24.
39. Upadhyay M, Yadav S, Patil S. Mini-implant anchorage for en-masse retraction of maxillary anterior teeth: a clinical cephalometric study. Am J Orthod Dentofacial Orthop. 2008;134(6):803–10.
40. Becker K, Pliska A, Busch C, Wilmes B, Wolf M, Drescher D. Efficacy of orthodontic mini-implants for en-masse retraction in the maxilla: a systematic review and meta-analysis. Int J Implant Dent. 2018;4(1):35.