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Review Article

ANCHORAGE LOSS AND INCLINATION DURING RETRACTION: A SYSTEMATIC REVIEW

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ABSTRACT

This review focused on anchorage lost and incisor inclination variation in the orthodontic retraction process. It compared the effectiveness of skeletal anchorage to that of conventional anchorage. It also sought to clarify how extraction and retraction mechanics and bracket type affect anchorage control and torque expression. The PRISMA 2020 guidelines were used in this review. A comprehensive literature search of the PubMed, Scopus, ScienceDirect, and EBSCOhost databases was performed to identify studies published between January 1992 and 2025. Prospective clinical trials, cohort studies, finite element analyses and case reports of orthodontic retraction with or without extractions were included. Data for anchorage control and incisor inclination were obtained, and qualitative analysis was performed. We evaluated risk of bias with Cochrane RoB 2 tool. Thirty-five studies fulfilled the criteria for inclusion. The majority of studies demonstrated that skeletal anchorage systems, such as mini-screws and miniplates, enable superior retention of anchorage and torque control compared to traditional techniques. Mass retraction was superior, faster method than two-step canine retraction especially with the use of skeletal anchorage. The mechanics, biomechanical system used and type of force were the major factors in determining anchor loss and angle change. The differences between MBT and self-ligating brackets were small, whereas clear aligners had mild to moderate control with the use of skeletal anchorage but generally decreasing trends. Traditional anchorage devices often result in loss of anchorage, which affect anterior retraction and torque control. Especially, the stability and biomechanical efficiency of skeletal anchorage devices, such as mini-screws are superior when retraction is performed en masse (EMR). Extraction protocol and force system are important for torque control as well as anchorage. The bracket type hardly matters with respect to anchorage reinforcement, and clear aligners have low torque control capabilities. Better-designed studies are necessary to establish evidence-based standardized parameters for anchorage and torque control.

Keywords: Anchorage loss, Inclination, Retraction, Biomechanical, Clinical trials.

INTRODUCTION

For the majority of adult patients, aesthetics is the main reason for orthodontic treatment. The leveling of the maxillary incisors' inclination is a common goal and is often achieved by the removal of the first maxillary premolars as part of the orthodontic procedure (Reyes Pacheco *et al*.,2020). In planning the biomechanical strategy for treating a patient orthodontically, an orthodontist has to evaluate not just the forces that will be required in order to obtain the targeted tooth movement and patient requirements, but also the unwanted tooth movement that may occur as a consequence of these acting forces (Davis D *et al*., 2018). Orthodontic therapy usually requires tooth movement that always comprises the control of anchorage, or resistance to undesirable tooth displacement (Arvind *et al*., 2021). This resistance is essential to cause intended tooth movements and to avoid untoward effects like loss of anchorage, the unwanted movement of the anchorage units (Arvind *et al*., 2021;

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Attia A. M *et al*., 2024). This phenomenon can take the form of mesialization of the posterior teeth during retraction of the anterior teeth, or distalization of the anterior teeth when posterior movement is planned (Attia *et al*., 2024). Successful orthodontic results depend heavily on effective anchorage control, particularly in situations calling for space closure by extraction or extraction and non-extraction treatments (Minaz and Amin, 2022). In addition, inclination, or axial angulation of teeth, is also a factor manipulated by and affecting anchorage, notably retraction mechanics (Qiang *et al*., 2024). The interrelatedness of anchorage and inclination greatly determines the predictability and efficiency of orthodontic force systems (Qiang *et al*., 2024). The complex biomechanical forces elicited in tooth movement, especially in retraction, directly affect both the amount of anchorage loss and the corresponding changes in tooth inclination, thus challenging orthodontists quite severely (Qiang *et al*., 2024). The current review aims to critically assess the biomechanical principles controlling anchorage loss and inclination change in orthodontic retraction in order to explain the differential effects of different force systems and appliance configurations on these important parameters. It will critically assess the methodologies used in current research to quantify anchorage loss and change of inclination, highlight deficiencies, and outline areas for further exploration. Additionally, it will synthesize existing evidence for the effectiveness of various anchorage control techniques, such as temporary skeletal anchorage devices and conventional mechanics, in preventing undesirable tooth movements and achieving optimal occlusal relations during retraction (Abu Arqub *et al*., 2023). This systematic review thus seeks to examine in a comprehensive manner the mechanisms, prevalence, and treatment of anchorage loss and inclination changes during orthodontic retraction treatment modalities.

MATERIALS AND METHODS

Reporting Guidelines and Protocol

This systematic review was carried out employing open approaches and according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) recommendations in order to find, assess, and synthesize all available findings (Figure 1).

Study Design

First, all duplicate reports were excluded. Then, all records identified were screened by looking at their titles and abstracts. The full texts of the articles that passed this preliminary screening were next assessed in order to ascertain whether they were eligible for inclusion into the final analysis. Just studies that met the pres-pecified inclusion criteria, which had been drawn up in line with the PICO framework, were considered eligible for the review.

Table 1. Based on the PICO framework.

Field	Description
Population (P)	Adolescents and adults patients receiving fixed orthodontic treatment involving anterior retraction (with or without premolar extractions). In addition, chosen typodont and finite element analysis (FEA) studies were incorporated if they yielded quantifiable data for anchorage loss or incisor inclination.
Intervention (I)	Any retraction mechanics/appliances used for space closure
Comparator (C)	Alternative treatment strategies or mechanics, such as skeletal anchorage vs conventional anchorage, en-masse vs two-step retraction, extraction vs non-extraction.
Outcome (O)	**Primary outcomes:** Studies reporting anchorage loss (mm) and/or incisor inclination change (degrees). **Secondary outcomes:** Retraction achieved, molar tipping/rotation, complications.

A systematic search of the literature was performed using PubMed, Science Direct, EBSCOhost, and Scopus online databases from January 1992 to 2025. Specific MeSH terms and words such as "Anchorage loss," "Inclination," and "Retraction" were used in the search. The screening began with the title and abstract review to categorize relevant papers. The full text of those articles for which the abstract m*et al*l inclusion criteria was then retrieved for in-depth evaluation. Full texts were also obtained for studies that qualified based on criteria even though they did not have adequate abstract content. Extra literature searching was also carried out through examination of the references of all included studies. Subsequently, the full text of articles whose abstracts satisfied all inclusion criteria was obtained for detailed assessment. Full texts were also retrieved for studies that met qualifying criteria despite having insufficient abstract content. Additionally, a more extensive literature search was performed by reviewing the references of all selected studies.

Data Extraction Process

The findings acquired from the search were imported into Microsoft Excel software. Furthermore, duplicates were manually eliminated using Microsoft Excel software. Two authors (Rehana Begum and Nidhi Angrish) independently evaluated the titles and abstracts of the unique reports to determine their eligibility for the study. After the screening process, relevant reports were identified, and the full texts were independently examined by two authors (Rehana Begum and Nidhi Angrish). Data were independently extracted by two authors (Rehana Begum and Nidhi Angrish) utilizing a pre-designed pro-forma. The collected data was carefully separated into distinct sections, such as the authorship and publication year, study design, extraction and non-extraction, anchorage system, bracket system and loop mechanics, parameters tested, and outcome.

Risk of Bias Assessment of Included Studies

Quality assessment of the included randomized controlled trials was conducted using the Cochrane Risk of Bias 2 (RoB 2) tool, which assesses five domains: the randomization process, deviations from the intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Each domain was rated as low risk, some concerns, or high risk, and these domain-level judgments were used to decide on the overall risk of bias for each study (Table – 2,3,4,5).

RESULTS AND DISCUSSION

The electronic search produced a total of 417 records (PubMed = 19, Scopus = 114, ScienceDirect = 268, and EBSCOhost = 16). After excluding 25 duplicates, 392 records were available for screening. Of these, 227 were eliminated at the title stage, 73 at the abstract phase, and 57 following full-text evaluation, primarily because they did not discuss anchorage loss, inclination changes, or retraction mechanics as key outcomes. Ultimately, 35 studies met the eligibility criteria and were included in the qualitative analysis. No reports were excluded due to issues with retrieval. The study selection process is depicted in the PRISMA 2020 flow diagram (Figure – 1).

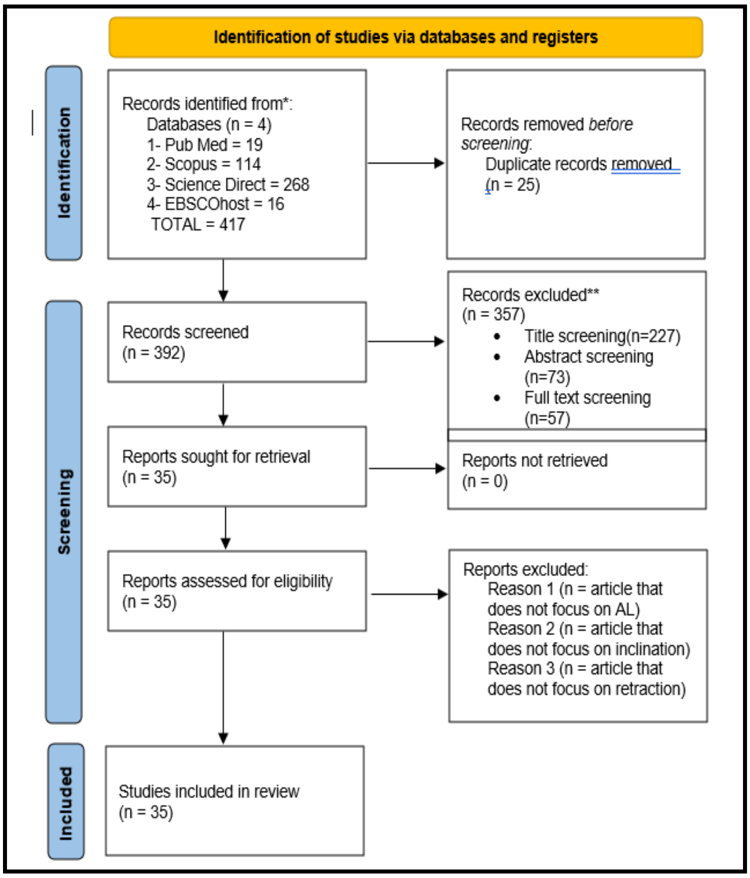

Figure 1. PRISMA 2020 flow diagram

A total of 35 studies were incorporated into this review, mainly consisting of randomized controlled trials in addition to prospective and retrospective clinical designs. The studies focused on anchorage loss and incisor inclination during orthodontic space closure following tooth extraction and were divided into four primary comparison groups:Comparison studies were conducted on frictionless mechanics of space closure. Results of anchorage were from slight loss with skeletal anchorage (Mini screws, miniplates) to greater mesial molar movement with traditional anchorage. Inclination changes were measured with cephalometric analysis, and some studies showed better control of torque with T-loop mechanics (Table- 2). Comparisons investigated the effect on premolar extractions and anchorage and inclination. First premolar extractions were most commonly studied, while certain studies evaluated second premolar extractions or non-extraction methods with distalization. Extraction techniques usually had higher anchorage requirements, while non-extraction methods with skeletal anchorage or aligners accomplished distalization with minimal loss of anchorage (Table –3). En-masse retraction with skeletal anchorage resulted in less anchorage loss and more controlled incisor inclination than traditional anchorage. Single canine retraction had variable anchorage demands, and implant-supported mechanics produced minimal mesial molar movement as opposed to conventional anchorage systems (Table- 4). Comparative studies of different types of bracket systems highlighted anchorage control, efficiency of treatment, and incisor inclination. MBT brackets, when combined with skeletal anchorage, efficiently preserved anchorage, while self-ligating brackets showed inconsistent results, with some reports of decreased treatment time without any differences in anchorage loss (Table– 5). In all comparisons, skeletal anchorage devices (mini-screws, miniplates, IZC screws) were frequently used and demonstrated superior anchorage preservation than conventional techniques like transpalatal arches and intermaxillary elastics. Outcome measures involved lateral cephalograms, CBCT, digital modeling, and study casts, with measurements of anchorage loss in millimeters and inclination changes in degrees.

Table 2. Conventional Loop Versus T-Loop Mechanics.

Conventional Loop Mechanics:

Author and year	**Type of study**	**Parameters checked**	**Extraction / Non-Extraction**	**Outcome**	**Bracket system and loops mechanics**	**Anchorage system**
Cakir E *et al.*, 2017	Case Report	Inclination Anchorage Support	**Extraction** (All 4 first premolars extracted after placing mandibular miniplates)	**Inclination** - U1-SN: ↓ from **94.4° → 89.5°** - IMPA: ↓ from **106.6° → 93.6°** - L1-NB: ↓ from **37.8° → 26.2°** - Interincisal angle: ↑ from **118.6° → 136.1°** **Anchorage Support** - Skeletal anchorage used (mandibular miniplates) - No quantification of molar movement (no numeric anchorage loss reported)	MBT brackets And Conventional loop	HYBRID ANCHOR - skeletal + intermaxillary
Escobar S. A *et al.*, 2007	Clinical Descriptive Study	Anchorage loss, Inclination, Distalization	Non-Extraction	**Anchorage Loss:** None observed **Inclination:** Molar – 11.3°, Premolar – 8.6°, Incisor – 2.5° palatal **Distalization Amount:** Molar – 6 mm, Premolar – 4.85 mm, Incisor retrusion – 0.5 mm	Conventional loop and bracket system not specified	skeletal anchor (BSP)
Le L. N *et al* ., 2024	Case Report	**Inclination**: U1 to FH, L1 to MP, Interincisal Angle; **Other Parameters**: Overjet, Overbite, ANB, Occlusion, Facial Asymmetry	**Extraction** (Upper 2nd premolars and lower left 1st premolar)	**Inclination changes**: U1-FH ↑ from 117.32° → 121.12°; L1-MP ↓ from 84.11° → 70.36°; Interincisal angle ↑ from 130.39° → 141.8° - **Overjet**: -1.26 mm → 2.1 mm; **Overbite**: 0.51 mm → 0.96 mm - **ANB angle**: -4.56° → 1.50° - **Occlusion**: Achieved Class I molars/canines on left, Class II on right - **Anchorage**: Maintained	MBT brackets And Conventional loop	Intra - arch anchorage (MEAW)

				using MEAW mechanics, elastics, and bite turbos - **Result**: Successful facial asymmetry correction without surgery		
T-Loop Mechanics						
Arvind P. T. R *et al*., 2021	Retrospective cephalometric study	1. Anchorage loss (molar mesial movement) 2. Pre-treatment interincisal angle	Extraction (all 1st premolars)	**1. Anchorage Loss:** - Implant-aided frictional mechanics (IAFM): 0.95 ± 0.36 mm - Frictionless mechanics with conventional anchorage (FMCA): 2.44 ± 0.46 mm (*p < 0.05*) **2. Interincisal Angle:** - IAFM: 100.15° ± 4.86° - FMCA: 99.45° ± 5.41° (no significant difference; groups were comparable)	T- loops and conventional preadjusted brackets	IAFM - Mini screw , FMCA - T loop with trans palatal arch
Attia A. M *et al*., 2024	Randomized Clinical Trial	1. Anchorage loss (cusp tip & root apex) 2. Molar rotation 3. Incisor tip & torque 4. Root resorption	Extraction (upper 1st premolars)	**1. Anchorage Loss:** Greater in frictionless group: Cusp tip: 3.98 mm vs 1.92 mm (*P = 0.014*) Apex: 1.58 mm vs 0.64 mm (not significant) **2. Molar Rotation:** Greater in frictionless group by 6.67° (*P = 0.02*) **3. Incisor Tip & Torque:** No significant differences between groups **4. Root Resorption:** Slightly more in lateral incisors; no significant intergroup difference	T- loops and 0.022 inch slot Roth brackets	TAD - Mini screw
Nandan H *et al*., 2023	Split-mouth randomized clinical trial	1. Duration of Retraction 2. Anchorage Loss 3. Distal Tipping of Canine 4. Molar Tipping 5. Canine & Molar Rotation	**Extraction** (maxillary first premolars)	**1. Duration:** – **Dual Force:** 73.8 ± 12.38 days – **T-loop:** 109.4 ± 16.71 days **2. Anchorage Loss:** – **Dual Force:** 0.60 ± 0.60 mm – **T-loop:** 2.40 ± 0.87 mm **3. Distal Canine Tipping:** – Dual Force: 7.15° ± 5.84 – T-loop: 13.5° ± 7.07 **4. Molar Tipping:** – Dual Force: 2.25° ± 2.41 – T-loop: 7.2° ± 7.34 **5. Canine Rotation:** – Dual Force: 1.85° ± 1.35 – T-loop: 17.6° ± 8.91 **Molar Rotation:** – Dual Force: 0.4° ± 1.9 (*NS*) – T-loop: 4.3° ± 3.88 ◆ Dual force retractor significantly reduced	MBT brackets And T- loops	Conventional anchorage with trans palatal arch

				treatment time, anchorage loss, and provided better 3D control		

Extraction:

Chopra S. S *et al*., 2017	Prospective comparative study	Anchorage loss (maxilla and mandible	**Extraction** (All four first premolars were extracted)	**Anchorage Loss** - Group I (Conventional): Maxilla – 2.00 ± 0.65 mm (28.08%), Mandible – 2.10 ± 0.75 mm (30%) - Group II (Implant): Maxilla – 0.20 ± 0.35 mm (2.86%), Mandible – 0.20 ± 0.35 mm (2.86%) **Treatment Duration** - Group I: 21.76 ± 1.54 months - Group II: 21.16 ± 1.62 months **Implant Success Rate** - 90.90% (5 implants failed in 3 patients) **Other Results** - Cephalometric changes (U1–NA, L1–NB, Nasolabial angle, etc.) noted - Group II had statistically significantly less anchorage loss - No significant difference in treatment duration	MBT brackets and no loops used	conventional anchorage
Qiang R *et al*., 2024	Finite Element Analysis	- Anchorage loss of posterior teeth - Tipping tendency and angulation (mesial/distal) - PDL stress distribution - Movement values of individual teeth - Maxillary vs Mandibular differences - Comparison of 1st vs 2nd	Both: 1st premolar (Model 1) and 2nd premolar (Model 2) extraction	**Anchorage Loss**: - Greater anchorage loss in **2nd premolar extraction cases** (Model 2) - Posterior teeth showed **more mesial tipping** in Model 2 - **Maxillary anchorage loss** higher than mandibular across all conditions **Inclination**: - Lingual inclination of anterior teeth more in Model 1 - Central incisors and	Clear aligners and no loops used	Invisalign system

		premolar extraction cases		canines showed distal tipping, greater in 1st premolar extraction **Other Findings**: - PDL stress higher in maxilla - Anchorage preparation design recommended: maxillary 1st molar: **8.80° distal (1st PM extraction), 16.03° distal (2nd PM)**		
Zhang L *et al*., 2022	Randomized Controlled Trial (3 groups)	1. Intrusion/extrusion 2. Buccolingual and mesiodistal tooth movement 3. Crown and root movement 4. Labiolingual and mesiodistal inclination angles of anterior & posterior teeth	Extraction (1st premolars)	**1.Intrusion:** DL group showed significant intrusion of maxillary 1st molars (−1.34 mm) and anterior teeth. DH group also had significant anterior intrusion. **2. Tooth Movement:** DL and DH groups showed distal molar movement; IL group showed mesial molar movement. **3. Inclination:** DL group had buccal (−6.92°) and distal (4.90°) inclination of 1st molars. DH group showed best lingual root torque control of incisors (lower inclination change and greater root lingual shift). **4. Clinical Implication:** Direct miniscrew anchorage with **high crimpable hooks (DH)** provides better control over incisor torque. Direct anchorage with **low hooks (DL)** causes greater molar intrusion and tipping. IL anchorage had weakest control over posterior anchorage.	MBT brackets and no loops used	Mini-screw anchorage
Tiwari A *et al*., 2023	Prospective Observational Split-mouth Clinical Study	1. Rate of Canine Retraction 2. Anchorage Loss 3. Chairside Time	Extraction (first premolars)	**1. Rate of Canine Retraction**: – Self-ligating: 0.9014 ± 0.3021 mm – Conventional: 0.8358 ± 0.2514 mm – *Not statistically significant* (P = .4081)	MBT brackets and no loops used	Trans palatal arch

				2. Anchorage Loss: – Self-ligating: 0.6985 ± 0.2514 mm – Conventional: 0.5474 ± 0.2633 mm – *Statistically significant* (P = .0210) **3. Chairside Time**: – Reduced with self-ligating brackets (qualitative observation)		
Alfailany D. T *et al*., 2023	Randomized controlled clinical trial (3-arm)	1. Rate of Canine Retraction 2. Anchorage Loss 3. Canine Rotation	**Extraction** (maxillary first premolars)	**1.Rate of Canine Retraction:** – **1st month**: TC = 2.79 mm, FCAPs = 2.00 mm, Control = 1.12 mm – **2nd month**: TC = 1.89 mm, FCAPs = 2.45 mm, Control = 1.22 mm – *TC showed 59.85% acceleration in 1st month, FCAPs 44%; effect reduced over time* **2. Anchorage Loss:** – **1st month**: TC = 0.57 mm, FCAPs = 0.76 mm, Control = 2.09 mm – *Significantly less in both surgical groups initially* **3. Canine Rotation:** – **End of Retraction**: TC = 5.76°, FCAPs = 2.73°, Control = 1.94° – *TC showed highest rotation*	MBT brackets and no loops used	Conventional anchorage

Table 3. Extraction Versus Non – Extraction **-Non – Extraction:**

Oberti G *et al*., 2009	Prospective Clinical Study	Anchorage loss, Inclination, Distalization, Vertical movement, Incisor retraction, Treatment effects	Non-Extraction	**Anchorage Loss:** None reported due to skeletal anchorage **Inclination:** Molar – 5.6°, Premolar – 5.4°, Incisor – 0.8° lingual **Distalization Amount:** Molar – 5.9 mm (crown), 4.4 mm (furcation); Premolar – 4.26 mm; Incisor – 0.53 mm **Other Parameters:** Bodily movement achieved; minimal	bracket system not specified and no loops used	skeletal anchorage

				vertical movement; treatment produced incisor retraction and improved molar Class I relationship without adverse effects		
Cai B *et al*.,2014	Case Report (2-phase treatment)	- ANB angle changes - Incisor inclination (Mx1-SN, Md1-MP) - Interincisal angle - E-plane - Cephalometric skeletal and dental measurements - Facial esthetics - Treatment stability (2-year follow-up)	Non-extraction	**Anchorage Loss**: Not significant , but Class III elastics were used with caution to avoid excessive maxillary molar extrusion. **Inclination**: - Md1-MP improved from 61.2° to 83.0° - Mx1-SN increased from 107.7° to 109.4° - Interincisal angle improved from 151.4° to 127.7° **Other Findings**: - SNA increased from 74.5° to 78.1° - ANB angle improved from –4.9° to –1.2° - Good facial esthetic improvement and stable result at 2-year follow-up.	MBT brackets and no loops used	Inter maxillary anchorage system
Xiao S *et al*., 2025	Finite Element Analysis	Inclination angle (IMPA) - Displacement (labial/lingual) - Movement - Contact force - Alveolar bone wall thickness	Non-extraction	**Inclination:** Pre-treatment IMPA: 68.93°, post-treatment: 72.53° ($P < 0.001$) . - Lingual crown inclination, labial root tendency observed - LFEH promotes labial movement - Lingual RCR promotes lingual control - LFEH + labial RCR design recommended for true vertical intrusion	Clear aligners and no loops used	Invisalign system
Chávez-Alvarez C *et al*., 2019	Retrospective CBCT-based longitudinal study	1. Maxillary incisor inclination (°) 2. Maxillary incisor position (mm)	Non-Extraction	**Inclination:** Increased significantly in bilateral cases (+10.41° to +12.79°); unilateral group showed significant change only on non-affected side (6.67°). **Protrusion:** Greater in bilateral group (+2.66 mm to +3.15 mm); unilateral group had mild change(1.74mm).	Conventional edgewise metal brackets (0.022x0.028 , synergy rocky mountain) and no loops used	palatal anchorage appliance

Fukunaga T *et al*., 2006	Case Report	1. Incisor inclination 2. Incisor intrusion 3. Periodontal condition 4. Overjet/overbite	Non-Extraction	**1. Inclination:** Maxillary incisors inclined lingually by 9.58° post-treatment and mandibular incisors inclined lingually by 7° **2. Intrusion:** Incisors intruded 2 mm at apex **3. Periodontal Condition:** Stable during and after treatment with regular maintenance **4. Overjet/Overbite:** Reduced from 7.5 mm to 4 mm (overjet), and from 4 mm to 3 mm (overbite); Class I canine relation achieved and maintained after 2-year retention	Preadjusted edgewise appliance and no loops used	skeletal anchor with titanium plates

Table 4. En – Mass Versus Individual Canine Retraction Mechanics.

En-Mass Retraction Mechanics:

Upadhyay M *et al*, 2008	Randomized Controlled Trial (n = 36, two groups: mini-implants vs. conventional anchorage)	Anchorage loss Inclination	**Extraction** (All 4 first premolars extracted in both groups)	**Anchorage Loss** - Group 1 (Mini-implants): Distal movement of molars (anchorage gain) - Group 2 (Conventional): Significant mesial movement of molars (U6-Sv: 3.22 mm), L6-Sv: 2.67 mm), and L6-MP: 1.22 mm) **Inclination** - Maxillary incisor: U1-SN reduced by 13.11° (G1) vs.	Preadjusted edgewise appliance (Roth prescription,0.022 x 0.028 in slot) and no loops used	skeletal anchorage (TAD)

				16.83° (G2) - Mandibular incisor: IMPA reduced by 14.22° (G1) vs. 10.72° (G2) **Soft-Tissue Changes** - Nasolabial angle increased by 11.67° in G1 (vs. 5° in G2) - Lower lip retraction: 4.78 mm (G1) vs. 3.11 mm (G2) **Other Findings** - Facial convexity and vertical dimension improved more in G1 - Retraction time not significantly different (G1: 8.61 mo, G2: 9.94 mo) - Mini-implant success rate: 93% (5 failures out of 72)		
Feng X *et al*., 2022	Retrospective study	Tooth angulation, Aligner predictability, Influencing factors, Root control, Crown-root morphology,	**Extraction** (First Premolars)	**Anchorage Loss**: Not assessed **Inclination**: Canines showed 15.03° deviation; Molars/Premolars had up to 8.77° less distal tipping	Clear aligners and no loops used	Intra maxillary anchor

		Attachment use		than designed **Other**: Poor aligner predictability (2–51%), influencing factors (arch shortening, tooth movement distances, initial angulation), and CBCT-based formulas for antitipping design recommended for better control.		
Blagitz M. N *et al*., 2020	Retrospective study	**Inclination** (1.NA, IMPA); Overjet; PAR index; Retention; Relapse rate	Mixed (7 patients underwent mandibular premolar extraction)	- **Maxillary incisor inclination (1.NA)**: ↑ from 28.5° to 31.2°. - **Mandibular incisor inclination (IMPA)**: ↓ from 85.4° to 84.8°. - **Relapse rate**: 30.6% (11 out of 36), defined as overjet <1 mm and/or Class III canine relation. - **Other factors**: Better orthodontic finishing (lower PAR index at T2), mandibular	Preadjusted edgewise appliance (0.022 x 0.028 in slot) and loops were not mentioned	HYBRID ANCHOR - intermaxillary + intra-arch dental anchor

				extractions, and lower initial 1.NA angle significantly reduced relapse risk. - **Retention**: No significant impact on stability.		
Iwata M *et al*., 2019	Case Report with 7-year follow-up	Cephalometric angles (SNA, SNB, ANB, SN-MP, U1-SN, L1-MP, interincisal angle), probing depth (PD), tooth mobility	Selective extraction	**Anchorage Loss**: Controlled via implants as anchorage. **Inclination**: – U1-SN reduced from 112.5° to 105.6° (better inclination) – L1-MP increased from 97.9° to 103.7° – Interincisal angle improved from 110.9° to 112.3° **Other Outcomes**: – Periodontal health stabilized (PD <3 mm) – No tooth mobility – Stable occlusion maintained at 7 years with improved esthetics and function	Clear aligners and no loops used	Invisalign system
Hung B. Q *et al*., 2020	Typodont simulation study using	1. Incisor and canine inclination changes	Extraction (simulated 1st premolar)	**1. Inclination:** - Central and lateral incisor	Lingual duet brackets and no loops used	micro-implant

	HITS	2. Vertical tooth position changes		inclination decreased more in single-wire groups, especially with 3-mm hooks (up to 19.69° in central incisors). - Double-wire with 6-mm hook had the least inclination change (16.59°). **2. Vertical Changes:** - Lateral incisors in single-wire with 3-mm hook showed maximum extrusion (2.83 mm). - Double-wire with 6-mm hook showed least extrusion (2.02 mm).		
Monga N *et al*., 2016	Retrospective clinical study	1. Anchorage Loss 2. Vertical and Angular Molar Movement 3. Incisor Retraction & Inclination	**Extraction** (all first premolars)	**1.Anchorage Loss** (with **indirectly loaded miniscrews**): – Maxilla: 1.27 ± 0.82 mm (crown), 1.10 ± 0.94 mm (root) – Mandible: 1.07 ± 0.87 mm (crown), 1.43 ± 1.06 mm (root) – Statistically significant **2. Vertical & Angular Molar**	Roth prescription conventional brackets (0.022x0.028,Rocky mountain orthodontics) and no loops used	Indirect Mini screw anchorage system

	Movement: – Maxillary molar extrusion: 0.20 ± 1.10 mm (*not significant*) – Mandibular molar extrusion: 0.57 ± 0.54 mm (*not significant*) – Molar tipping: Maxilla −2.43°, Mandible −0.03° (*not significant*) **3. Incisor Retraction & Inclination:** – Maxilla: 5.77 mm (crown), 2.63 mm (root); −9.6° tipping – Mandible: 5.43 mm (crown), 2.00 mm (root); −7.73° tipping – *Statistically significant distal movement and intrusion*	

Sakthi S. V *et al*., 2014	Comparative clinical study	1. Rate of Retraction 2. Anchorage Loss 3. Effect of RAP (Regional Acceleratory Phenomenon)	**Extraction** (all four 1st premolars)	**1. Rate of Retraction:** – **Maxilla:** 1.8 mm/month (study) vs. 1.02 mm/month (control) – **Mandible:** 1.57 mm/month (study) vs. 0.87 mm/month (control) – *Significant acceleration in first 2 months due to RAP* **2. Anchorage Loss:** – **Maxilla:** 0.86 mm (study) vs. 1.8 mm (control) – **Mandible:** 0.51 mm (study) vs. 1.6 mm (control) – *Statistically significant difference* **3. RAP Effect:** – Enhanced retraction for ~4 months – Anchorage segment remained relatively stationary during this period.	Roth prescription conventional brackets (0.022 slot) and no loops used	Conventional anchorage

Individual Canine Retraction Mechanics:

Kurt G *et al*., 2017	Prospective comparative study (DAD vs. conventional distalization)	Anchorage loss Inclination	**Extraction** (First premolars extracted in both groups)	**Anchorage loss** - DAD: No significant first molar mesialization - DG: 1.98 ± 1.16 mm of molar mesialization (anchorage loss) **Inclination (Tipping)** - Canine tipping: DAD	Conventional 0.018 stainless steel brackets and no loops	grp 1 - tooth borne anchorage , grp2- intermaxillary anchorage

				– 11.48° ± 4.37°, DG – 13.64° ± 9.54° **Rate of Retraction** - DAD: 7.9 mm in 11.8 days (0.67 mm/day) - DG: 5.29 mm in 200 days (0.03 mm/day) **Other Observations** - No root resorption or vitality loss in DAD group - DAD resulted in significant time reduction without anchorage loss	used	
Lotzof L *et al*., 1996	Prospective in vivo study	Anchorage Loss	**Extraction** (First premolars extracted in one or both arches for space closure)	**Anchorage Loss** - Tip-Edge: Mean = **1.71 mm** - Straight Wire: Mean = **2.33 mm** **Rate of Canine Retraction** - Tip-Edge: **1.88 mm/3 weeks** - Straight Wire: **1.63 mm/3 weeks** **Other** - No statistically significant difference in rate or anchorage loss - Inclination was **not measured** in this study	MBT brackets and no loops used	reciprocal anchorage
Davis D *et al*., 2018	In vivo study	1. Rate of canine retraction 2. Anchorage loss 3. Molar inclination	Extraction (1st premolars)	**1. Rate of Canine Retraction:** Maxilla: 0.95 mm/month (implant side) vs. 0.82 mm/month (molar side) – *statistically significant (P=0.012)* Mandible: 0.81 mm/month (implant) vs. 0.76 mm/month (molar) – *not significant* **2. Anchorage Loss:** Maxilla: 0.1 mm (implant) vs. 1.3 mm (molar) Mandible: 0.06 mm (implant) vs. 1.3 mm (molar) – *highly significant (P<0.05)* **3. Molar Inclination:** Maxilla: 0.3° (implant) vs. 2.45° (molar) Mandible: 0.19° (implant) vs. 2.69° (molar) – *statistically*	Preadjusted edgewise appliance (roth 0.028 slot) and no loops used	Mini implant anchorage

				significant (P=0.000 and 0.001)		
Sukurica Y *et al*., 2007	Prospective clinical study	1. Canine distalization 2. Anchorage loss 3. Tooth inclination 4. Periodontal status 5. Vitality 6. Root resorption	Extraction (1st premolars)	**1.Canine Distalization:** Mean movement: 5.35 ± 1.22 mm in 12–28 days (mean 14.65 days) **2. Anchorage Loss:** Mean: 1.2 ± 0.83 mm **3. Inclination:** Canines tipped distally (mean 9.1°); no significant change in molars **4. Periodontal Health:** increase in gingival sulcus depth; other indices not significantly changed **5. Vitality:** 7/20 canines regained vitality after 6 months **6. Root Resorption:** not clinically significant	Conventional fixed appliance and no loops used	SADO , ANCHOR from 1st 2nd molar
Thiruvenkatachari B *et al*., 2006	Pilot clinical study	1. Anchorage Loss (with & without implants) 2. Implant Stability	**Extraction** (all first premolars)	**1.Anchorage Loss:** – **With Implant:** 0 mm in both maxilla and mandible – **Without Implant (Molar anchorage):** Maxilla: 1.6 mm Mandible: 1.7 mm – *Statistically significant anchorage loss on molar-anchored side* **2. Implant Stability:** – All implants remained stable throughout retraction period – No deformation or failure; (1 case of minor inflammation resolved with oral hygiene)	Bracket system not specified and no loops used	Implant Vs Conventional molar anchor
Kharkar V. R *et al*., 2010	Prospective clinical study	1. Time Required for Retraction 2. Canine Tipping 3.	**Extraction** (maxillary 1st premolars)	**1. Time for Canine Retraction:** – Mean: **12.5 ± 0.5 days** **2. Canine Tipping:** – Mean tipping: **10.63° ± 0.25°** **3. Anchorage Loss:** – **Sagittal:** 0.32 ± 0.37 mm	Bracket system not specified and no loops used	custom- made - tooth borne intraoral distractor

		Anchorage Loss (sagittal & vertical) 4. Root Resorption		– **Vertical:** 0.55 ± 0.33 mm **4. Root Resorption:** – **None observed** in any case **Other Findings:** – All teeth remained **vital** throughout follow-up – **No ankylosis** or pathological changes reported		
Davis S *et al*., 2019	Split-mouth randomized clinical trial	1. Rate of Canine Retraction 2. Anchorage Loss 3. Canine Tipping 4. Canine Rotation 5. Patient Discomfort (VAS)	**Extraction** (maxillary first premolars)	**1. Rate of Retraction:** – **MS:** 1.188 ± 0.232 mm/week – **TLS:** 0.708 ± 0.157 mm/week – *Significant difference (P < 0.001)* **2. Anchorage Loss:** – **MS:** 0.791 mm – **TLS:** 0.250 mm – *Higher in MS (P < 0.001)* **3. Canine Tipping:** – **MS:** 6.645° – **TLS:** 1.229° – *More tipping in MS (P < 0.001)* **4. Canine Rotation:** – **MS:** 2.42° – **TLS:** 5.65° – *More control with MS* **5. VAS Discomfort Score:** – **MS:** 28.00 – **TLS:** 49.45 – *Patients reported significantly less discomfort with MS*	MBT brackets and no loops used	Conventional anchorage , skeletal anchor with mini implant

Table 5. Mbt Brackets Versus Self – Ligating Brackets System.

Mbt Brackets System:

Uribe F *et al*., 2015	Case Report	ANB, Wits appraisal, Maxillary & Mandibular incisor inclination, Interincisal angle, Overjet, Overbite,	Extraction	- **Anchorage loss**: Controlled using miniscrews; no significant anchorage loss reported. - **Inclination**: • Maxillary incisors: 11.9° → 20.2° • Mandibular incisors: 17.2° → 26.7° - **Interincisal angle**: 152° → 129° - **ANB**: –1.2° → 3.6° - **Wits**: –4.9 mm → 1.9 mm - **Treatment time**: Reduced to 12 months using modified surgery-first	MBT brackets and no loops used	skeletal anchorage

		Skeletal changes		protocol - **Other**: Improved esthetics, occlusion, midline alignment, minimal bone loss, and high patient satisfaction		
Venugopal A *et al*., 2020	Case Report	Overjet, Overbite, Incisor inclination, Gingival display, ANB, U1-SN, U1-NA, IMPA, Inter-incisal angle, Lip position (E-line), FMA	**Extraction** (All four first premolars and third molars)	**Anchorage Loss:** Initially lost due to poor biomechanics; corrected with IZC and anterior miniscrews **Inclination**: • U1-SN: 113.18° → 92.28° • U1-NA: 30.85° → 12.64° • IMPA: 92.02° → 88.64° • Interincisal angle: 115.1° → 138.27° **Overjet**: 6 mm → 1 mm **Overbite**: 90% → 1.5 mm **ANB**: 6.57° → 4.52° **Other**: 4 mm anterior intrusion achieved; gingival display significantly reduced; lip competence restored; E-line improved from 4.13 mm to 0.07 mm. Long-term stability maintained over 2 years.	MBT brackets and no loops used	skeletal anchorage (TAD)
Reyes Pacheco *et al*., 2020	Randomized controlled clinical split-mouth trial	Anchorage loss, Canine distalization rate, Tipping, Bone density, PDL space	**Extraction** (First premolars)	**Anchorage Loss**: Comparable between test and control groups **Canine Distalization**: L-PRF group showed faster movement – **3.32 mm vs. 2.15 mm** (control) over 6 weeks **canine Inclination**: control side; min-4.15° and max-15.19° , experimental side; min-1.69° and max-14.53° **Other**: CBCT showed no damage to alveolar bone or root; L-PRF accelerated movement safely; no resorption or loss of vitality observed	MBT brackets and no loops used	conventional anchorage

Self – Ligating Brackets System:

He X *et al*., 2025	Retrospective study	Root resorption, Alveolar bone height and thickness, Incisor inclination, Root length	Extraction (bilateral maxillary first premolar extraction)	**Anchorage Loss:** Not evaluated **Inclination:** mean reduction in inclination of the maxillary incisors - FA group-7.27° and CA group-8.74° **Other Parameters:** Root resorption was quantified in mm; significant reduction in root length post-treatment; alveolar bone height and thickness decreased labially; labial alveolar remodeling and root shortening observed pre- vs. post-surgery	Self ligating brackets and no loops used	skeletal anchorage (TAD)
Li J *et al*., 2020	Case Report	Inclination, Torque control, Space	**Extraction** (Both Maxillary First	**Anchorage Loss:** Prevented using controlled force application and staged treatment **Inclination:** U1-SN changed from 82.8° to 102° (bodily movement,	Self ligating bracket system and	skeletal anchorage (TAD)

	management, Tooth-size discrepancy (TSD), CBCT-based root position and bone morphology	Premolars)	not tipping) **Distalization Amount:** Not applicable **Other Parameters:** No IPR required due to precise torque control; CBCT confirmed parallel roots, stable occlusion, and no root resorption; 2-stage torque strategy used; Achieved ideal occlusion and Class I canine/molar relationship.	no loops used

IMPA- Incisor Mandibular Plane Angle, BSP – Bone Supported Pendulum, MEAW -Multiloop Edgewise Arch wire, IAFM- Implant Aided Frictional mechanics, FMCA- Frictionless Mechanics With Conventional Anchorage, TAD- Temporary Anchorage Device, PM- Premolar, PDL- periodontal ligament, DL - Direct Miniscrew Anchorage With Low Crimpable Hooks, IL- Indirect Miniscrew Anchorage With Low Crimpable Hooks, DH- Direct Miniscrew Anchorage With High Crimpable Hooks, TC- Traditional Corticotomy, FCAPs- Flapless Cortico-Alveolar Perforations, HITS- Heat Induction Typodont System, DAD- Dento-Alveolar Distraction, DG- Distalization Group, SADO- Stimulated Alveolar Distraction Osteogenesis, MS- Marcotte Spring, TLS- T loop spring, L-PRF- Leukocyte and Platelet Rich Fibrin, FA- Fixed Appliance, CA- Clear Aligners.

The quality of the chosen studies was evaluated on an individual basis. The Cochrane Risk of Bias 2.0 tool was utilized to assess the Quality Assessment Tool for Randomized Controlled Trials. Five distinct criteria were examined, such as the clearly defined randomization process, deviations from the intended interventions, any missing outcome data, the measurement of outcomes, and the selection of reported results. In (Figure 2: Conventional Loop Vs T-Loop Mechanics) Four of the studies included were deemed to have a low risk of bias, one study was considered not applicable, and another study was identified as having a high risk of bias, primarily associated with the randomization process. In (Figure 3: Extraction Vs Non-Extraction Protocols) Eight of the included studies were classified as low risk of bias, one study was classified as not applicable, and the other study was classified as high risk of bias and was predominantly found in the randomization process. In (Figure 4: En-masse Vs Individual Canine Retraction) Twelve of the included studies were classified as low risk of bias, one study was classified as not applicable, and the other study was classified as high risk of bias and was predominantly found in the randomization process. In (Figure 5: MBT Brackets vs. Self-Ligating Brackets) Four of the included studies were classified as low risk of bias and the other study was classified as high risk of bias and was predominantly found in the randomization process. These analyses showed differences in the quality of the studies, which may affect the reliability of their findings.

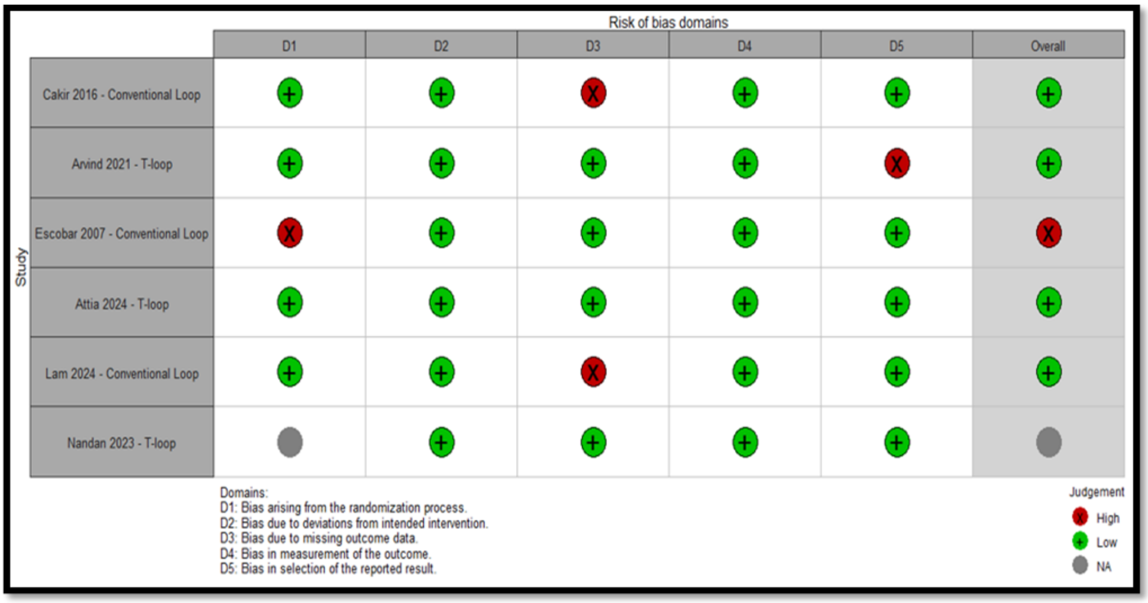

Figure 2. Conventional Loop Versus T-Loop Mechanics.

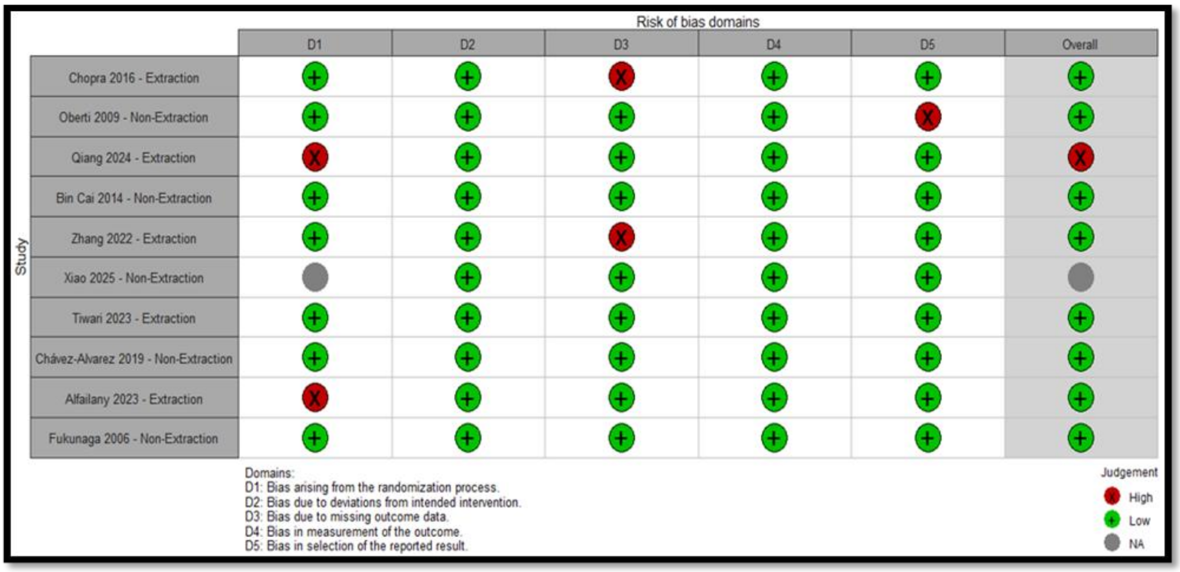

Figure 3. Extraction Versus Non-Extraction Protocols.

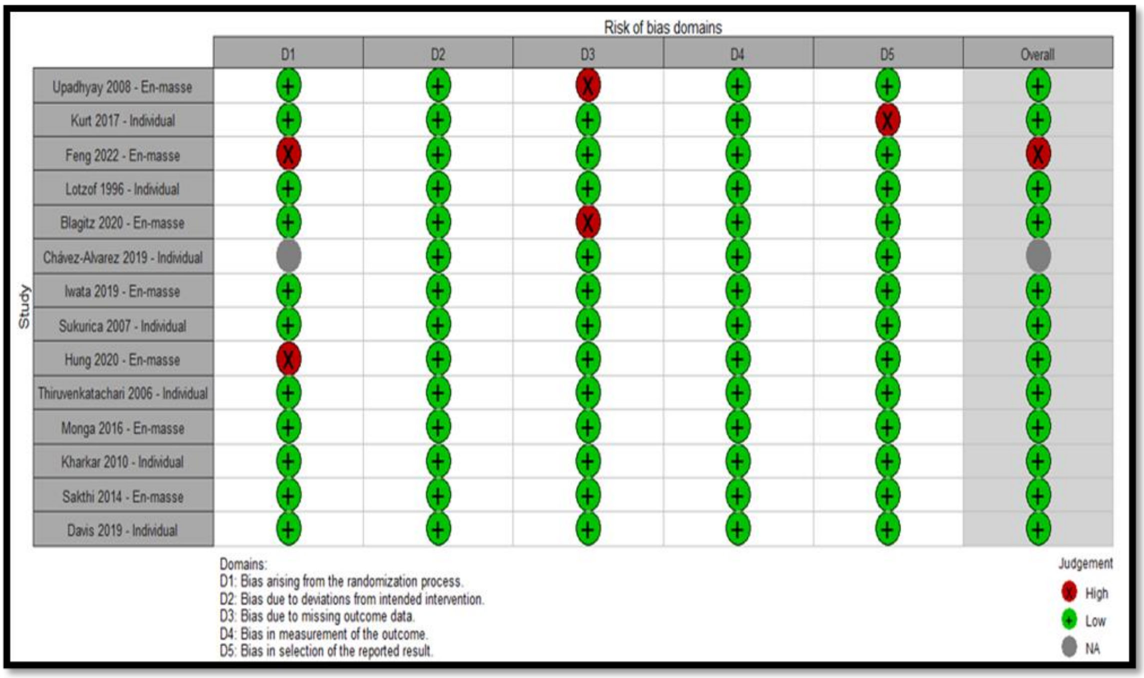

Figure 4. En-masse Versus Individual Canine Retraction.

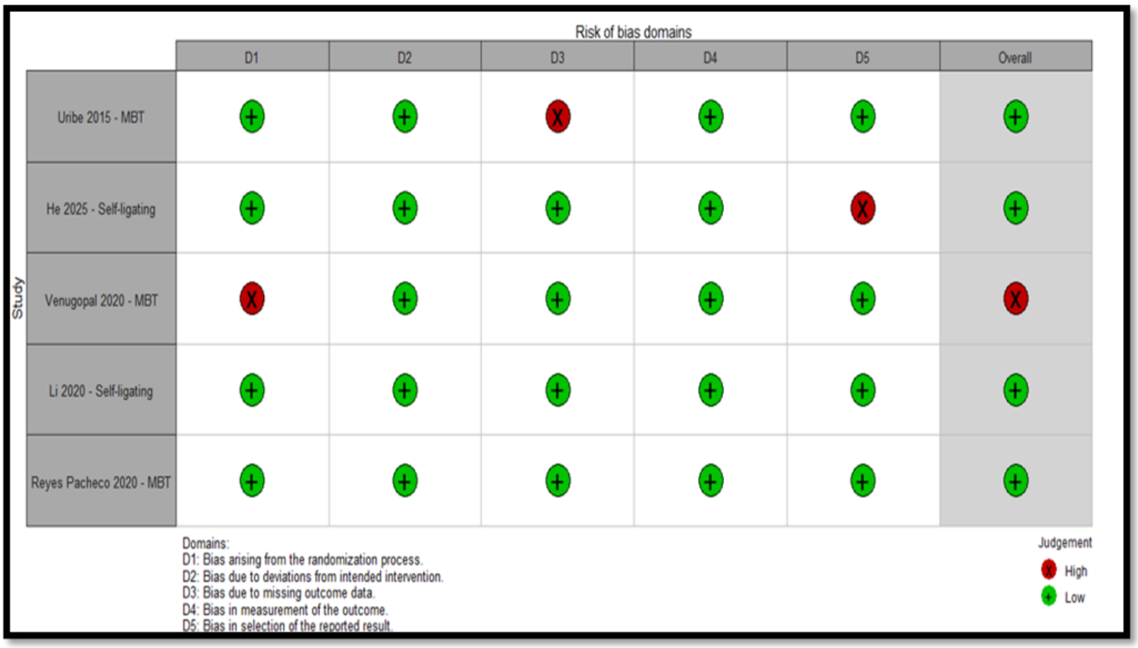

Figure 5. MBT Brackets Versus Self-Ligating Brackets.

This systematic review evaluated loss of anchorage and incisor inclination changes associated with various retraction mechanics in orthodontic treatment. Thirty-five eligible studies comprising randomized controlled trials, cohort studies, and finite element analyses were reviewed. The cumulative evidence emphasizes that both torque control and anchorage reinforcement are key considerations for effective treatment and remain a source of major clinical challenges. Recurring finding of the studies is the ability of skeletal anchorage devices in minimizing anchorage loss. The movement of miniscrews and miniplates was appreciably lower (usually less than 1 mm) when compared to traditional anchorage systems such as trans palatal arches, Nance appliances, or intermaxillary elastics (Upadhyay M *et al*, 2008; Arvind P. T. R *et al.*, 2021; Chopra *et al.*, 2017; Davis D *et al.*, 2018). There was even a study that found cases of distal movement of molar resulting in an enhancement of anchorage by the utilization of skeletal anchorage (Upadhyay M *et al*, 2008). Conversely, most traditional anchorage systems frequently indicated anchorage loss between 1.3 mm and more than 3 mm, with adverse effects on the outcome of anterior retraction (Chopra S. S *et al.*, 2017; Attia A. M *et al.*, 2024). Extraction protocols and biomechanical strategies tended to significantly impact control of incisor inclination. En-masse retraction with miniscrew anchorage always provided superior torque control over a two-step canine retraction protocol, which led to larger tipping moments (Nandan H *et al.*, 2023; Davis D *et al.*, 2018). Finite element simulations further confirmed that second premolar extraction resulted in greater mesial tipping of posterior teeth and greater anchorage requirements than first premolar extraction, highlighting the need for case-specific biomechanic planning (Qiang R *et al.*, 2024). T-loop mechanics have greater control over anterior root movement than traditional loop systems but frequently require meticulous control of anchorage to avoid molar mesialization (Attia A. M *et al.*, 2024). Comparison of bracket systems revealed that differences between MBT and self-ligating prescriptions were small in terms of anchorage retention and inclination change (Tiwari A *et al.*, 2023; He X *et al.*, 2025). The degree of anchorage loss primarily was determined by the reinforcement strategy and not by the bracket design. Aligners, particularly when combined with skeletal anchorage, exhibited promise for reducing posterior anchorage loss in non-extraction distalization protocols, although issues with the ability to consistently deliver reliable root torque remain (Feng X *et al.*, 2022; Iwata M *et al.*, 2019). Note that the outcome measures also differed considerably between included studies. Whereas most clinical studies used lateral cephalograms, others used CBCT or digital models, which offered more reliable three-dimensional assessments (Reyes Pacheco *et al.*, 2020; Zhang L *et al.*, 2022). Methodological variability, small sample sizes, and varied follow-up periods were common limitations, making it hard to compare findings. Furthermore, a number of studies were at moderate to high risk of bias, particularly in terms of randomization and concealment of allocation, and this should moderate the confidence in the conclusions reached. The long-term stability of incisor inclination and maintenance of anchorage was poorly reported and is a field open to future research. Overall, this review is focusing on the fact that anchorage preservation and torque control are affected by several factors: extraction pattern, retraction mechanics, and reinforcement strategy. Skeletal anchorage provides the most predictable results, while traditional anchorage procedures are more prone to unwanted molar movement and loss of torque control.

CONCLUSION

Through the evaluation of several studies, it was evident that traditional anchorage systems undergo extensive anchorage loss, which can impair the efficacy of anterior retraction and torque control. Within the limitation of this review, skeletal anchorage devices, particularly miniscrews, represent the best way to minimize anchorage loss and increase incisor inclination control during orthodontic retraction. En-masse retraction with TADs is more biomechanically efficient compared to a two-step canine retraction. Extraction pattern selection and force system design play a critical role in determining both the posterior teeth anchorage requirements and anterior torque control, highlighting the importance of individualized biomechanical planning. Traditional brackets and self-ligating brackets showed similar levels of performance, indicating that anchorage reinforcement is more important than bracket selection. Although clear aligners have the potential for distalization mechanics, their reliability for root torque is unknown. Well-designed randomized controlled trials with standard outcome measures, three-dimensional imaging, and long-term follow-up are needed to develop stronger evidence-based recommendations for controlling anchorage and torque during retraction.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

REFERENCES

Abu Arqub, S., Al-Moghrabi, D., Iverson, M. G., Farha, P., Alsalman, H. A., & Uribe, F. (2023). Assessment of the efficacy of various maxillary molar intrusion therapies: a systematic review. *Progress in orthodontics*, *24*(1), 37.

Alfailany, D. T., Hajeer, M. Y., Al-Bitar, M. I., Alsino, H. I., Jaber, S. T., Brad, B., & Darwich, K. (2023). Effectiveness of Flapless Cortico-Alveolar Perforations Using Mechanical Drills Versus Traditional Corticotomy on the Retraction of Maxillary Canines in Class II Division 1 Malocclusion: A Three-Arm Randomized Controlled Clinical Trial. *Cureus*, *15*(8), e44190.

Arvind, P. T. R., Ramasamy, N., & Rengalakshmi, S. (2021). Comparative Evaluation of Anchorage Loss with Implant-Aided Retraction and Frictionless Mechanics with Conventional Anchorage in Bimaxillary Protrusion Cases. *Journal of long-term effects of medical implants*, *31*(4), 21–26.

Attia, A. M., Shibl, L. A., Dehis, H. M., Mostafa, Y. A., & El-Beialy, A. R. (2024). Evaluation of anchorage loss after en masse retraction in orthodontic patients with maxillary protrusion using friction vs frictionless mechanics: randomized clinical trial. *The Angle orthodontist*, *94*(5), 532–540.

Blagitz, M. N., Almeida, G. A., & Normando, D. (2020). Factors associated with the stability of compensatory orthodontic treatment of Class III malocclusion in the permanent dentition. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *158*(5), e63–e72.

Cai, B., Zhao, X. G., & Xiang, L. S. (2014). Orthodontic decompensation and correction of skeletal Class III malocclusion with gradual dentoalveolar remodeling in a growing patient. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *145*(3), 367–380.

Cakir, E., Malkoç, S., & Kirtay, M. (2017). Treatment of Class II malocclusion with mandibular skeletal anchorage. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *151*(6), 1169–1177.

Chávez-Alvarez, C., Arriola-Guillén, L. E., Rodríguez-Cárdenas, Y. A., Ruíz-Mora, G. A., Fiori-Chincaro, G., Dias-Da Silveira, H. L., & Aliaga-Del Castillo, A. (2019). Changes in maxillary incisor inclination and position after traction of unilateral vs bilateral maxillary impacted canines in nonextraction treatment: A cone-beam computed tomography study. *American journal of orthodontics and dentofacial orthopedics: official* *publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *156*(6), 767–778.

Chopra, S. S., Mukherjee, M., Mitra, R., Kochar, G. D., & Kadu, A. (2017). Comparative evaluation of anchorage reinforcement between orthodontic implants and conventional anchorage in orthodontic management of bimaxillary dentoalveolar protrusion. *Medical journal, Armed Forces India*, *73*(2), 159–166.

Davis, D., Krishnaraj, R., Duraisamy, S., Ravi, K., Dilip, S., Charles, A., & Sushil, N. C. (2018). Comparison of Rate of Canine Retraction and Anchorage Potential between Mini-implant and Conventional Molar Anchorage: An *In vivo* Study. *Contemporary clinical dentistry*, *9*(3), 337–342.

Davis, S., Sundareswaran, S., & James, J. (2019). Comparative evaluation of the efficiency of canine retraction using modified Marcotte and T-loop retraction springs - A split-mouth, randomized clinical trial. *Journal of orthodontic science*, *8*, 9.

Escobar, S. A., Tellez, P. A., Moncada, C. A., Villegas, C. A., Latorre, C. M., & Oberti, G. (2007). Distalization of maxillary molars with the bone-supported pendulum: a clinical study. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *131*(4), 545–549.

Feng, X., Jiang, Y., Zhu, Y., Hu, L., Wang, J., Qi, Y., & Ma, S. (2022). Comparison between the designed and achieved mesiodistal angulation of maxillary canines and posterior teeth and influencing factors: First premolar extraction treatment with clear aligners. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *162*(2), e63–e70.

Fukunaga, T., Kuroda, S., Kurosaka, H., & Takano-Yamamoto, T. (2006). Skeletal anchorage for orthodontic correction of maxillary protrusion with adult periodontitis. *The Angle orthodontist*, *76*(1), 148–155.

He, X., Zhou, X., Cui, Y., Li, X., Zhou, Y., Xia, Y., Zhu, M., Liu, J., & Mao, L. (2025). Comparative analysis of root resorption and alveolar remodeling in maxillary incisors during orthodontic-orthognathic surgical treatment of skeletal Class III malocclusion. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *167*(5), 591–603.e6.

Hung, B. Q., Hong, M., Yu, W., & Kyung, H. M. (2020). Comparison of inclination and vertical changes between single-wire and double-wire retraction techniques in lingual orthodontics. *Korean journal of orthodontics*, *50*(1), 26–32.

Iwata, M., Saito, A., Kuroda, Y., Shinohara, T., & Tanaka, E. (2019). Interdisciplinary therapy for severe periodontitis with Angle Class II Division 1 malocclusion: A case report with 7-year follow-up. *Journal of the American Dental Association (1939)*, *150*(11), 960–971.

Kharkar, V. R., & Kotrashetti, S. M. (2010). Transport dentoalveolar distraction osteogenesis-assisted rapid orthodontic canine retraction. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics*, *109*(5), 687–693.

Kuc, A. E., Kotuła, J., Nahajowski, M., Warnecki, M., Lis, J., Amm, E., Kawala, B., & Sarul, M. (2022). Methods of Anterior Torque Control during Retraction: A Systematic Review. *Diagnostics (Basel, Switzerland)*, *12*(7), 1611.

Kurt, G., İşeri, H., Kişnişçi, R., & Özkaynak, Ö. (2017). Rate of tooth movement and dentoskeletal effects of rapid canine retraction by dentoalveolar distraction osteogenesis: A prospective study. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *152*(2), 204–213.

Le, L. N., Thi, T., & Le, K. P. V. (2024). Non-surgery Treatment with MEAW Technique in Skeletal Class III Malocclusion and Facial Asymmetry in Adults: A Case Report. *The Open Dentistry Journal*, *18*(1).

Li, J., Pan, Y., Yang, A., & Lei, L. (2020). Treatment in a patient with congenital loss of both mandibular lateral incisors and severely retroclined maxillary central incisors. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *158*(6), 868–877.

Lotzof, L. P., Fine, H. A., & Cisneros, G. J. (1996). Canine retraction: a comparison of two preadjusted bracket systems. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *110*(2), 191–196.

Minaz, M. D., & Amin, V. (2022). Comparison and Measurement of Molar Anchorage Loss during En-Masse Retraction Using Mini-Implant and Conventional Mechanics. *Saudi Journal of Oral and Dental Research*, *7*(9), 213–219.

Monga, N., Kharbanda, O. P., & Samrit, V. (2016). Quantitative and qualitative assessment of anchorage loss during en-masse retraction with indirectly loaded miniscrews in patients with bimaxillary protrusion. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *150*(2), 274–282.

Nandan, H., Kumar, C. S., & Jha, P. (2023). Comparison of Maxillary Canine Retraction Using Split-Mouth Design With Dual Force Cuspid Retractor and T-loop Segmental Arch: A Split-Mouth Randomized Clinical Trial. *Cureus*, *15*(2), e35288.

Oberti, G., Villegas, C., Ealo, M., Palacio, J. C., & Baccetti, T. (2009). Maxillary molar distalization with the dual-force distalizer supported by mini-implants: a clinical study. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *135*(3), 282.e1–283.

Qiang, R., Gao, J., Wang, Y., Wang, W., Ma, Y., & Jin, Z. (2024). Anchorage loss of the posterior teeth under different extraction patterns in maxillary and mandibular arches using clear aligner: a finite element study. BMC oral health, 24(1), 1204.

Reyes Pacheco, A. A., Collins, J. R., Contreras, N., Lantigua, A., Pithon, M. M., & Tanaka, O. M. (2020). Distalization rate of maxillary canines in an alveolus filled with leukocyte-platelet-rich fibrin in adults: A randomized controlled clinical split-mouth trial. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *158*(2), 182–191.

Sakthi, S. V., Vikraman, B., Shobana, V. R., Iyer, S. K., & Krishnaswamy, N. R. (2014). Corticotomy-assisted retraction: an outcome assessment. *Indian journal of dental research: official publication of Indian Society for Dental Research*, *25*(6), 748–754.

Sukurica, Y., Karaman, A., Gürel, H. G., & Dolanmaz, D. (2007). Rapid canine distalization through segmental alveolar distraction osteogenesis. *The Angle orthodontist*, *77*(2), 226–236.

Thiruvenkatachari, B., Pavithranand, A., Rajasigamani, K., & Kyung, H. M. (2006). Comparison and measurement of the amount of anchorage loss of the molars with and without the use of implant anchorage during canine retraction. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *129*(4), 551–554.

Tiwari, A., Aafaque, S., Rizwana, Y., Quadri, S. A., Kanagasabapathy, B., Villuri, C., Babu, J. S., Swarnalatha, C., & Nayyar, A. S. (2023). Canine retraction and anchorage loss using self-ligating and conventional brackets with sliding mechanics: A split-mouth clinical study. *Journal of orthodontic science*, *12*, 70.

Upadhyay, M., Yadav, S., Nagaraj, K., & Patil, S. (2008). Treatment effects of mini-implants for en-masse retraction of anterior teeth in bialveolar dental protrusion patients: a randomized controlled trial. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *134*(1), 18–29.e1.

Uribe, F., Agarwal, S., Shafer, D., & Nanda, R. (2015). Increasing orthodontic and orthognathic surgery treatment efficiency with a modified surgery-first approach. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *148*(5), 838–848.

Venugopal, A., Manzano, P., Arnold, J., Ludwig, B., & Vaid, N. R. (2020). Treating a severe iatrogenic gingival exposure and lip incompetence - a challenge worthwhile. *International orthodontics*, *18*(4), 874–884.

Xiao, S., Cheng, C., Li, H., Li, L., Shen, C., Feng, Q., Zhao, Y., Duan, Y., Xia, L., Chu, F., & Fang, B. (2025). Biomechanical analysis of clear aligners for mandibular anterior teeth intrusion and its clinical application in the design of new aligner attachment. *Progress in orthodontics*, *26*(1), 11.

Zhang, L., Guo, R., Xu, B., Wang, Y., & Li, W. (2022). Three-dimensional evaluation of maxillary tooth movement in extraction patients with three different miniscrew anchorage systems: a randomized controlled trial. *Progress in orthodontics*, *23*(1), 46.