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Exploring the Potential of Segmental T-Loop Mechanics in Orthodontic Correction of Buccally Erupted Ectopic Canines: A Clinical Case Report

[1]Debdeep Kuila, Junior Resident, Department of Orthodontics and Dentofacial Orthopaedics, Dr Ziauddin Ahmad Dental College and Hospital, AMU, Aligarh, UP.

[2]Prof. (Dr.) Sanjeev Kumar Verma, Professor and Head, Department of Orthodontics & Dentofacial Orthopaedics, Dr. Z A Dental College, AMU, Aligarh, Uttar Pradesh.

[3]Dr. Aiswareya G, Senior Resident, Department of Orthodontics and Dentofacial Orthopaedics, Dr. Z A Dental College, AMU, Aligarh, Uttar Pradesh.

[4]Dr. Pramod Kumar Yadav, Assistant Professor, Department of Periodontia and Community Dentistry, Dr. Z A Dental College, AMU, Aligarh, Uttar Pradesh.

[5]Dr. Ameen Ashraf M.P, Private Practitioner.

Corresponding Author: Dr. Pramod Kumar Yadav, Assistant Professor, Department of Periodontia & Community Dentistry, Dr. Z A Dental College, AMU, Aligarh, Uttar Pradesh.

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Abstract

This clinical case report evaluates the biomechanical effectiveness of segmental T-loop mechanics using 0.017 × 0.025-inch Titanium Molybdenum Alloy (TMA) wire in correcting buccally erupted ectopic maxillary canines associated with severe crowding. A 22-year-old male with Class I molar relation, skeletal Class II pattern, and hyperdivergent growth exhibited bilateral buccally displaced canines and arch length discrepancy. Following extraction of all first premolars, retraction was carried out using Burstone's segmented arch technique with preactivated T-loops (15° α and 30° β bends) positioned near the posterior segment to reinforce anchorage. Delivering approximately 250 g of continuous, physiologic force, the loops enabled precise, frictionless tooth movement, supplemented by a transpalatal arch and mandibular lingual holding arch. Over 22 months, complete canine alignment, optimal overjet and overbite, and improved nasolabial angle and lip profile were achieved. Cephalometric and radiographic analyses confirmed favourable soft-tissue balance, stable skeletal relationships, and parallel root alignment. The segmental

T-loop provided a predictable moment-to-force (M/F) ratio, facilitating controlled tipping and translation while minimizing anchorage loss and unwanted side effects common with sliding mechanics. Compared with continuous arch systems, this approach offers superior three-dimensional control, reduced frictional losses, and biologically efficient force systems. In conclusion, the customized segmental T-loop represents a biomechanically sound, conservative, and efficient technique for managing ectopic canines and crowding, promoting controlled tooth movement, anchorage preservation, and long-term stability in orthodontic treatment.

Keywords: Segmental mechanics, T-loop, Titanium Molybdenum Alloy, ectopic canine, frictionless retraction, orthodontic biomechanics, controlled tooth movement.

Introduction

Anterior teeth retraction represents a critical phase in fixed orthodontic therapy, requiring precise three-dimensional control to achieve optimal function, aesthetics, and post-treatment stability. Space closure following premolar extraction is routinely performed in orthodontics, with canine retraction constituting a key step in this process. Two main approaches are employed for space closure: friction (sliding) and frictionless (loop or non-sliding) mechanics.[1] The latter, utilizing loop designs such as the T-loop, offers distinct advantages by eliminating friction between the bracket and archwire, thereby enabling more efficient and controlled tooth movement.[2]

The T-loop retraction spring, introduced within Burstone's segmented arch mechanics, allows precise modulation of force systems through differential moments generated between the anterior and posterior segments. Adjustments to the alpha (anterior) and beta (posterior) arms of the loop provide effective control over horizontal and vertical tooth movement, ensuring efficient space closure with minimal anchorage loss.[3]

Ectopically erupted or highly placed maxillary canines, often associated with crowding, present a common clinical challenge. In such cases, the use of segmental T-loop mechanics facilitates individual canine retraction before anterior alignment, reducing round tripping, preserving anchorage, and preventing undesirable proclination of incisors.[4]

This paper highlights the biomechanical advantages and clinical efficiency of segmental T-loop mechanics in the retraction and repositioning of ectopically placed canines, emphasizing controlled, predictable, and physiologically favourable tooth movement.[5]

Case Report

A 22-year-old male patient reported to the Department of Orthodontics & Dentofacial Orthopaedics, ZADC & H, AMU with the chief complaint of irregularly placed upper and lower front teeth. The patient was medically and physically healthy with no relevant family or medical history.

Extraoral examination (Figure 1) revealed a symmetrical and well-balanced face with a mesocephalic head form and mesoprosopic facial pattern. The patient exhibited a straight to mildly convex facial profile, competent lips, and an average nasolabial angle. The smile was symmetrical but non-consonant, with average buccal corridors and 95-100% display of the upper incisors during smiling. Facial proportions showed nearly equal facial fifths and slightly increased lower facial third, suggestive of an Normodivergent to hyperdivergent growth pattern.

Intraoral examination (Figure 1) showed full complement of permanent dentition up to the second molars, with erupting third molars in all quadrants except lower left

quadrant which is horizontally impacted noted radiographically (Figure 3). Angle's Class I molar and not defined canine relationships were present bilaterally. Severe crowding was observed in both arches (Maxilla-14 mm; Mandible-10 mm), with buccally erupted maxillary canines. The mandibular midline was shifted 2 mm to the right in relation to the facial and maxillary midline, with slightly increased overjet (5 mm) and overbite (4 mm). The upper and lower arches were symmetric and U shaped.

Radiographic findings **(**Figure 2**)** revealed normal alveolar bone levels and absence of any pathology. Cephalometric analysis indicated skeletal Class II relationship with an orthognathic maxilla and retrognathic mandible (ANB = 5°), vertical growth pattern (FMA=29°;SN-MP = 30°;Y axis=65°), and proclined upper and retroclined lower incisors (U1-NA =6 mm & 30°, L1-NB =5 mm & 21°). The soft tissue analysis demonstrated well-balanced lips with a harmonious(Mild convex) facial profile.(Table 1)

Treatment Objectives

The primary objective was to resolve anterior crowding and achieve functional, stable occlusion. Skeletally, the aim was to maintain the existing Class II jaw relationship and the hyperdivergent growth pattern without compromising the facial profile or airway space.

Dentally, the goals were to correct the ectopic eruption of canines, align and level both arches, and establish proper incisor inclination. Space creation was planned through extraction of the four first premolars. Maximum anchorage was required; hence, a trans palatal arch with acrylic button was used in the maxillary arch and a lingual arch in the mandibular arch to prevent mesial movement of molars. Extraction of impacted 38 was also advised.

The occlusal objectives were to achieve a Class I molar and canine relationship, maintain ideal overjet and overbite, and establish canine-guided occlusion.

Soft-tissue objectives were to maintain lip competence, preserve facial harmony, and achieve an aesthetically pleasing profile.

Treatment Plan & Progress

Segmented mechanics retraction protocol was planned following extraction of all first premolars to correct proclined incisors and ectopically erupted canines while maintaining anchorage with a transpalatal arch. Fixed MBT appliances with 0.022" × 0.025" slot brackets were placed, and segmented T-loop mechanics using 0.017" × 0.025" TMA wires were employed between canine brackets and molar buccal tubes for individual canine retraction in maxilla. Each T-loop incorporated 15° alpha and 30° beta bends, positioned closer to the posterior segment for enhanced anchorage and activated by pulling the distal arm 3 mm distal to the first molar at each visit (Figure 3 & 4). Simultaneously mandibular bonding was done and continuous arch mechanics with lace back of canines was performed. Reactivations of T-loop were performed every six to eight weeks over four to five months, achieving complete canine retraction with satisfactory root parallelism. Subsequently, full maxillary bonding was completed, and continuous arch mechanics were initiated using the following archwire sequence for alignment and retraction: 0.014" NiTi, 0.016" NiTi, 0.016" × 0.022" NiTi, 0.017" × 0.025" SS , 0.019" × 0.025" SS, and 0.016" SS for finishing with settling elastics. Passive lacebacks were used to prevent canine mesial tipping, and figure of eight with 0.009" SS ligature wire was used to maintain the closed space. Additional torque control was applied to mandibular canines. After 22 months of active treatment, optimal alignment, occlusion, and facial profile improvement

were achieved. The patient was satisfied with the results and declined the removal of impacted third molar.

Treatment Outcome

Post-treatment results demonstrated successful achievement of all treatment objectives. Class I molar and canine relationships were established and maintained bilaterally, contributing to a stable and functional occlusion with proper anterior and canine guidance. Maxillary and mandibular crowding were effectively corrected, resulting in well-aligned arches with acceptable overbite (3 mm) and overjet (3 mm).(Figure 6)

Cephalometric analysis confirmed significant improvement in the soft-tissue profile, including enhanced nasolabial angle, reduced lip protrusion, and establishment of an adequate lip seal. The upper anterior teeth exhibited ideal inclination, the lower incisors showed improved, though slightly proclined, angulation appropriate for the patient's lip position and occlusal harmony.(Figure 7)(Table 1)

Radiographic evaluation revealed parallelism of canine and premolar roots on the panoramic radiograph, indicating proper root alignment and healthy periodontal support. Gingival health was satisfactory, and post-treatment intraoral and extraoral records showed improved smile aesthetics and facial balance. (Figure 7)

All appliances were removed, and upper Hawley's retainer and lower lingual bonded retainers were delivered for one year of full-time wear followed by night time wear; third molar extraction was advised to maintain long-term stability.

Discussion

Epidemiology and Etiopathogenesis

Maxillary canine impaction ranks second only to mandibular third molar impaction in frequency, with reported incidences ranging from 0.8% to 2.8% (Shah et al., 1978; Grover & Lorton, 1985). The anomaly exhibits a distinct female predominance, occurring approximately twice as often in females (1.2%) as in males (0.5%) (Dachi & Howell, 1961). Ectopic or buccally erupted canines represent one of the most commonly encountered anomalies in orthodontic practice, with an overall prevalence of 1–2% in the general population.[6]

The aetiology of ectopic canines is multifactorial, involving a complex interplay between genetic and local environmental influences. Localized factors such as arch length deficiency, prolonged eruption paths, or disturbances in the dental follicle may influence the trajectory of eruption. Buccal impactions are typically associated with insufficient space in the arch and a more vertical developmental position, while palatal impactions—more frequent in females and Caucasians—are characterized by a horizontal path within denser palatal bone, making spontaneous eruption unlikely.[7]

Biomechanical Considerations of Segmental T-Loop Mechanics

Among the various modalities for canine retraction—including elastics, coil springs, sliding jigs, and lace-backs—the segmented T-loop represents a refined biomechanical approach for achieving controlled, frictionless tooth movement. Introduced by Stoner (1960) and later analysed by Burstone and Koenig (1974), the T-loop spring enables precise three-dimensional control of the force system by modulating the moment-to-force (M/F) ratio through alterations in loop geometry, preactivation bends, and placement.[8]

In the present case, a 0.017×0.025″ Titanium Molybdenum Alloy (TMA) T-loop was used to retract bilaterally ectopic maxillary canines. TMA was selected for its optimal combination of formability, resilience, and low load-deflection rate, which ensures a more continuous and biologically compatible force delivery.

The loop was fabricated and preactivated according to Burstone's guidelines to achieve approximately 250 g of force, generating a retraction rate of nearly 0.8–0.9 mm per month.[9]

Adjustments in the alpha and beta arms of the loop allowed control over the M/F ratio and thus the nature of tooth movement. For controlled tipping, a lower M/F ratio was maintained without preactivation, while translation demanded an increased M/F ratio achieved via preactivation bends. The loop's posterior placement, closer to the molar tube, enhanced anchorage by increasing the beta moment. An active cinch-back was applied to augment distalization and limit anterior anchorage loss.[10]

The segmented T-loop also produced a counterbalancing moment to prevent distal tipping and maintain root parallelism, while torque control ensured the canine root moved safely away from the lateral incisor. As retraction progressed, a vertical force component was incorporated to extrude the canine into occlusion. The reciprocal intrusive force on molars was effectively neutralized using a transpalatal arch, which maintained vertical control and prevented molar extrusion.[11]

Clinical Performance and Treatment Efficiency

Within seven months of treatment, bilateral alignment of ectopic maxillary canines was successfully achieved. The use of segmented mechanics allowed precise force application and prevented undesirable "round-tripping" associated with continuous archwire mechanics. Additionally, first-order antirotation bends were incorporated to minimize distal-in/mesial-out rotational tendencies often observed in labially placed canines.[12]

The use of frictionless mechanics with T-loop springs provided several clinical advantages:

- Controlled three-dimensional tooth movement (translation, tipping, and torque).
- Reduced frictional losses compared to sliding mechanics.
- Independent control of force magnitude and moment generation.
- Enhanced posterior anchorage through selective loop positioning.

These features contributed to efficient space closure, improved biomechanical predictability, and stable treatment outcomes.

Comparison with Alternative Retraction Techniques

Several mechanical systems are available for canine retraction, including elastic chains, coil springs, sliding jigs, lace-backs, and extraoral traction. However, most rely on frictional sliding mechanics, which are prone to binding, uncontrolled tipping, and anchorage loss. In contrast, the T-loop provides frictionless controlled tooth movement with continuous force application.[13]

Alternative spring designs such as the PG spring (Paul Gjessing, 1985) and the closed helical loop have been proposed. The PG Spring, fabricated from stainless steel, generates a favourable M/F ratio of 8–9:1 without requiring preactivation bends. However, stainless steel has a higher load-deflection rate, leading to force decay and reduced biological efficiency. Conversely, the TMA-based T-loop delivers lighter, more physiologic forces conducive to tooth translation and root control.[14]

Finite element analyses (Chacko et al., 2010) have confirmed that T-loops produce lower but more evenly distributed stresses within the periodontal ligament, thereby minimizing hyalinization and root resorption risks. Nonetheless, a limitation of T-loop mechanics is the high sensitivity to fabrication accuracy—minor variations in loop height or activation can significantly alter the resultant force system.[15]

Clinical Implications and Advantages of Segmental Mechanics

Segmental T-loop mechanics offer distinct advantages for managing ectopic canines, particularly when anchorage preservation and precise control of force vectors are critical. The sectional approach isolates the canine segment, minimizing unwanted movement of adjacent teeth and reducing the risk of anchorage loss. Moreover, by delivering continuous, light, and controlled forces, T-loops promote favourable biologic responses and reduce treatment time compared to traditional continuous arch mechanics.[5]

In this clinical case, the combined use of premolar extractions, transpalatal arch anchorage, and segmented T-loop mechanics achieved efficient correction of buccally erupted canines while avoiding unnecessary tooth movement.

Conclusion

The present clinical case highlights the effectiveness of Segmental T-loop mechanics using a 0.017 × 0.025″ Titanium Molybdenum Alloy (TMA) wire in managing buccally erupted ectopic canines associated with crowding and proclination. The precisely fabricated T-loop provided an optimal moment-to-force (M/F) ratio, allowing controlled tooth movement in all three planes of space. By employing segmental mechanics rather than continuous arch mechanics, unwanted side effects such as anchorage loss and undesirable tooth tipping were minimized.

This approach enabled predictable and efficient distalization and vertical correction of the ectopic canine, contributing to a well-balanced occlusion, improved facial profile, and stable treatment outcome. The use of a customized segmental T-loop thus represents a biomechanically sound, conservative, and versatile technique for individual canine retraction in complex cases with limited arch space. Overall, segmental T-loop mechanics can be considered a valuable adjunct in contemporary orthodontics for achieving precise three-dimensional tooth control in ectopic canine correction.

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Legend Figures and Tables

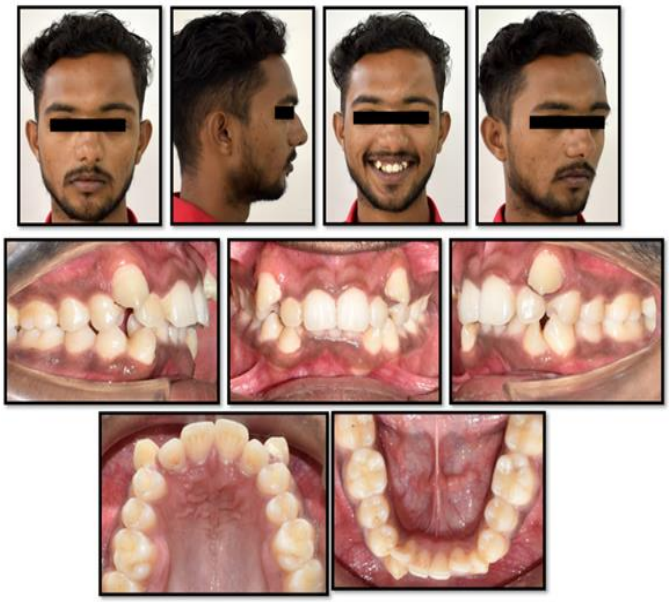

Figure 1: Pre Treatment Extraoral and Intraoral Photographs

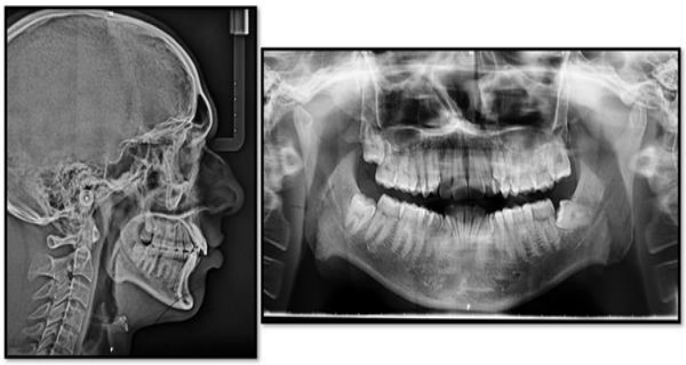

Figure 2: Pre Treatment Lateral cephalogram and OPG

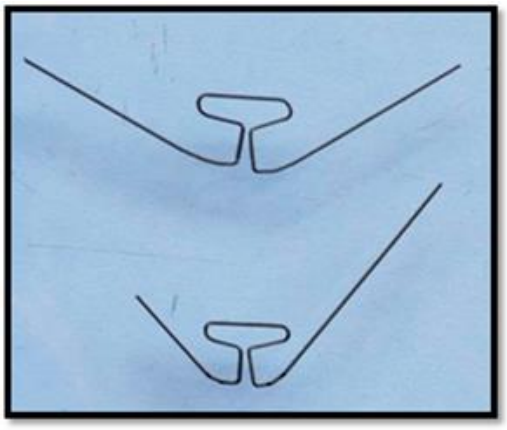

Figure 3: 017 x 025 TMA T loop with Pre activation bends

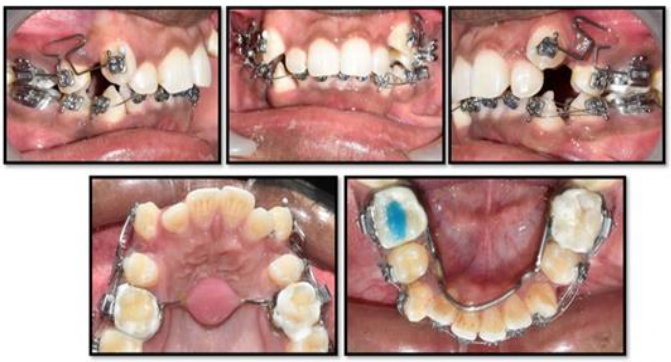

Figure 4: 017 x 025 TMA T loop and TPA in Maxilla and Passive lace back with Continuous arch mechanics and Lingual holding arch in mandible

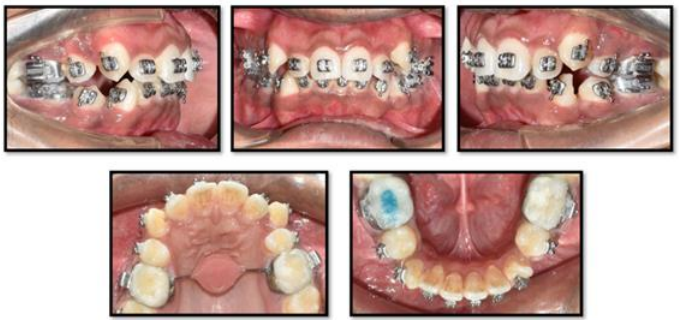

Figure 5: Intraoral photographs after 6 months follow up

Figure 6: Post Treatment Extraoral and Intraoral Photographs

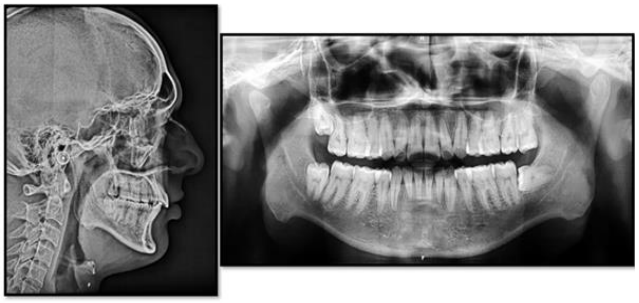

Figure 7: Post Treatment Lateral Cephalogram and OPG

Table 1: Cephalometric Analysis Pre and Post Treatment

Hard Tissue Findings		
Parameters	Pre Treatment	Post Treatment
SNA	79°	78°
SNB	74°	73°
ANB (3.12± 1.8)	5°	5°
Wits (female = 0 mm; male =-1mm)	2.3 mm	2.4 mm
Growth Pattern		
FMA (23.83±2°)	29°	27°
SN-MP (32-35°)	30°	29°
Y Axis (59.62°±3)	65 °	63°
Upper anterior facial height (45%)	40%	41%
Lower anterior facial height (55%)	60%	59%
Dentoalveolar Findings		
Mx 1 to NA: 4.92±2.05mm	5.8 mm	5.2 mm
Mx 1 to NA: 24.02±5.82°	31°	30°
Md 1 to NB (6±1.7mm)	4.8 mm	5.2 mm

Md 1 to NB (27±4.3 °)	21°	26°
IMPA (93°)	93°	98°
Soft Tissue Findings		
Upper lip to E line (-4mm)	-3.5 mm	-4.7 mm
Lower lip to E line (-2 mm)	2.3 mm	2.5 mm
Nasolabial angle (102+/-8)	103° Upper =14° Lower =89°	102° Upper=13° Lower=89°