Reviewing Canine Distalization Techniques: From Traditional Approaches to Modern Innovations

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ABSTRACT

Introduction: Over the years, canine retraction or distalization has been accomplished through frictional and non-frictional mechanics by orthodontists. The search for new methods to achieve the desired movement of canine in the least time possible has led to the development of various new methods.

Objective: This article is aimed at providing a synthesis of the recent literature about the novel methods of canine distalization techniques.

Method: An electronic literature search was conducted between January 2015 and December 2023 using the keywords “canine” and “retraction method”. Additionally, manual searches in the reference lists of the articles included were also carried out.

Result: The information obtained from the selected articles was arranged in an organized manner for ease of understanding under the given subheadings in the article.

Keywords: Canine Retraction, Canine Distalization, Canine & Loop, Canine & Sliding, Corticotomy.

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Introduction

Canine, the cornerstone tooth of the arch, because of its structure and strong anchorage resistance, presents unique treatment challenges for orthodontists. Its relationship to other teeth in the arch and its strategic location in relation to the bone influences not just intra-oral equilibrium but also extra-oral aesthetics. Cases involving the extraction of premolars followed by canine retraction need to be analyzed thoroughly to select the most optimal approach to achieve these results. Although since time immemorial orthodontists have experimented with various techniques to retract canines into the premolar space without losing anchorage, no single technique has proven to be 100% reliable. Some have tried overcoming the difficulties associated with the correct movement of this long-rooted tooth without taxing the anchorage, while others simply tried to decrease the overall treatment time by the use of efficient mechanics. The most recent systematic review regarding the canine retraction technique was published in 2015 which looked at the most effective and least harmful canine retraction methods and techniques using evidence-based methods.[1] Since then, different techniques have been introduced in the literature to increase the efficiency of canine movement. Therefore, the aim of this article is to provide an overview of the most recent additions to the effective canine distalization techniques that have been proposed in recent years.

Materials and Methods

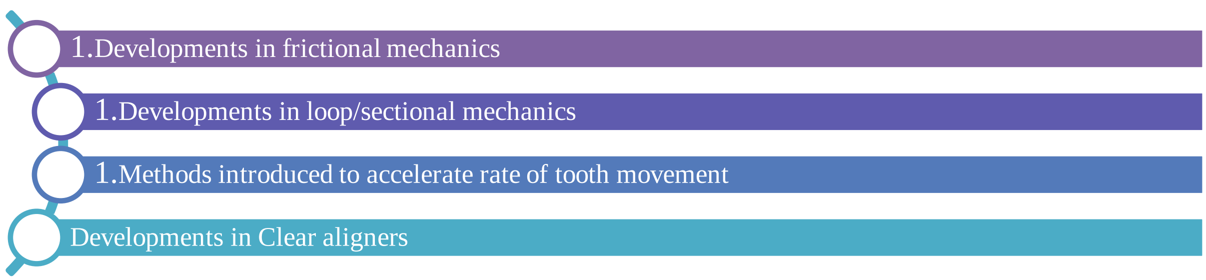
From January 2015 to December 2023, an electronic literature search was conducted using PubMed, Science Direct, and Google Scholar. Manual searches in the reference lists of the included articles were also conducted.

Results

A total of 360 studies were produced by the search strategy. Following the elimination of duplicates and title/abstract screening, the studies that satisfied the eligibility requirements were added to the review. The data collected from the chosen articles was then categorised under the designated headings in the article's discussion section for easy comprehension.

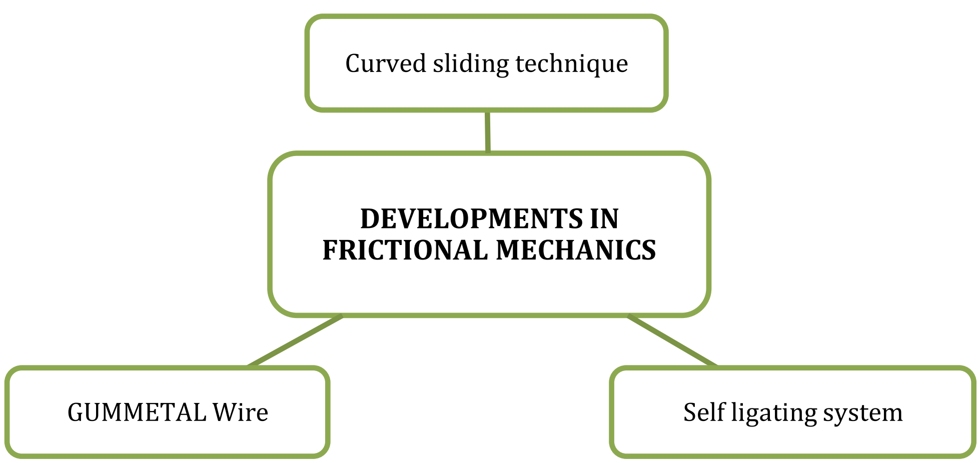
Discussion

The following headings can be used to group case studies, in vivo research, and in vitro studies pertaining to developments in canine distalization.



Developments in Frictional Mechanics

Frictional mechanics traditionally used to retract canines can include a number of methods which have been compared and contrasted since 2015 to provide evidence for making a better clinical decision. When direct sliding was compared with power-arm sliding, the former was found to be more efficient and convenient. No discernible difference in the rate of canine retraction, tipping, rotation, or root resorption between NiTi closed coil springs and elastomeric chains used as force delivery systems has been found although pain experienced during elastomeric chain retraction has been reported to be more significant.



1. **The Curved Sliding Technique:** This is a new method for canine retraction that considers the following conditions:
1. Achieve desired movements with minimal adverse effects.
2. Expedite the process.
3. Fewer wire bending.
4. Range of action.
5. Consistent with modern orthodontic improvements.[1]

This novel canine retractor (Figure 1) is made of 0.019 × 0.025-inch SS wire. It includes the following parts:

- **Connector:** Adapt the connection section to passively insert into the canine bracket and tie it with a ligature wire.
- **The bend:** This component seeks to lower the bent part slightly below the tube. This allows the wire to form the appropriate curve, with a bend length of 3 mm.
- The **curved portion** of the wire makes a 4 cm radius circle.
- The **power arm** has a length of 7 mm and is attached to the connection section.[1]

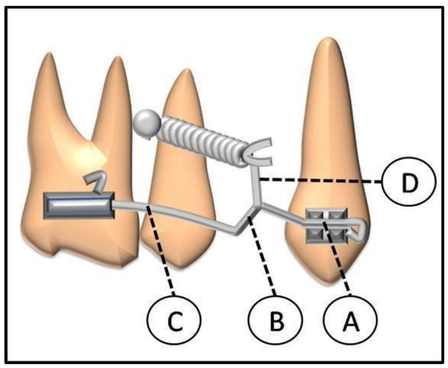


Figure 1: Canine retractor design.[1] A: Connector B: The bend, C: Curved portion, D: Power arm.

Canine retraction employing the curved sliding method and direct miniscrew anchorage demonstrated exceptional canine axis control as well as precise rotational control during retraction. The curved sliding method has a good retraction rate due to reduced friction, as the second premolar bracket is not engaged during the retraction phase.[1]

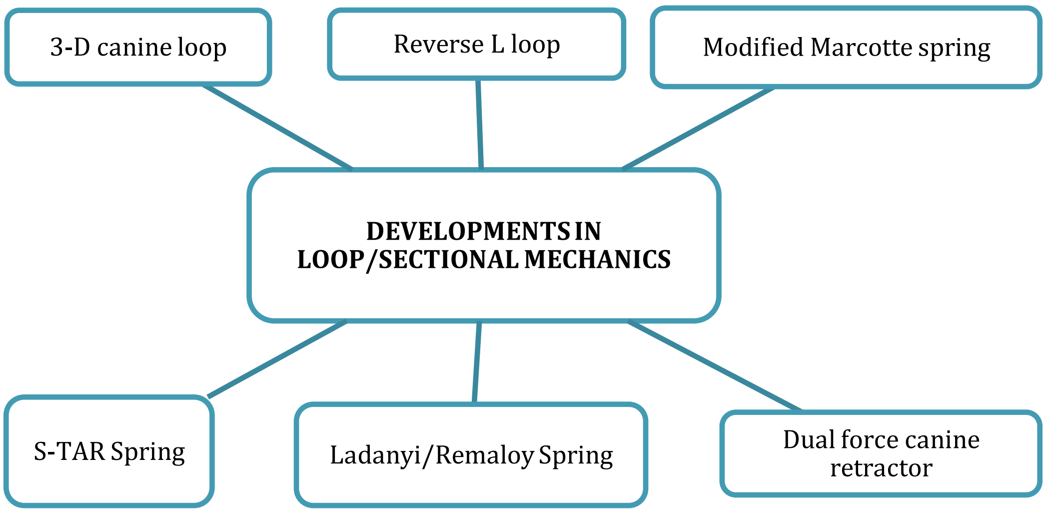
2. **GUMMETAL® wire:** A study by Ravlyk et al., conducted a pilot split-mouth randomized controlled trial to compare maxillary canine retraction using a recently developed TiNb alloy wire (GUMMETAL®) with stainless steel (SS) archwires. They treated twelve subjects with first-premolar extractions. The canine retraction was started using TiNb coil springs. Digital models were used to measure canine movement and 3-dimensional changes at 0, 4, 8, and 12 weeks. Results showed similar results obtained between GUMMETAL® and SS in terms of canine retraction, rate of movement, or 3-dimensional changes. Although GUMMETAL® demonstrated potential for space closure mechanics, studies with large sample sizes are needed for further confirmation.[2]

3. **Self- ligating Systems:** A study by Tiwari et al.[3] aimed to compare the efficiency of self-ligating brackets (SLB) versus conventional brackets (CB) in terms of canine retraction rate and anchorage loss during orthodontic treatment. Twenty-five patients requiring first premolar extraction were included in the prospective, observational study. Canine retraction was performed using both types

of brackets, and the rate of retraction was assessed every 4 weeks for 3 months. Anchorage loss was also measured using an acrylic guide plug. Statistical analysis revealed a significant correlation between the two bracket types in terms of retraction rate.

Self-ligating brackets exhibited double the displacement in some cases and significantly reduced chair-side time compared to conventional brackets. On the other hand, in terms of anchorage loss no significant difference in anchorage loss between the CB and SLB groups have been reported by a systematic review and meta-analysis conducted in 2020 by Malik et al.[4]

Developments in Loop/Sectional Mechanics



1. **Reverse L loop**

In addition to the M/F ratio, clinicians have to consider the vertical forces on both sides of a loop when choosing a closing loop. A V-bend-like force system found in vertical U and T-loops produces an extrusive force at the shorter end. A profound overbite could be the outcome of such extrusive forces. Step bends or V-bends at the longer ends are two techniques that have been utilized to produce an intrusive force at the shorter loop ends. However, step bends in off-centered T-loops result in more tipping movement at the canine bracket and more body movement at the posterior side because they erase the increased moment associated with off-centered T-loops while simultaneously increasing the intrusive force.[5,6,7]

Using a reversed L-loop (Figures 2 and 3) as a plain closing loop with intrusive force at the canine bracket from the horizontal activation, the study by Techalertpaisarn P and Versluis A illustrates an alternative.[8]

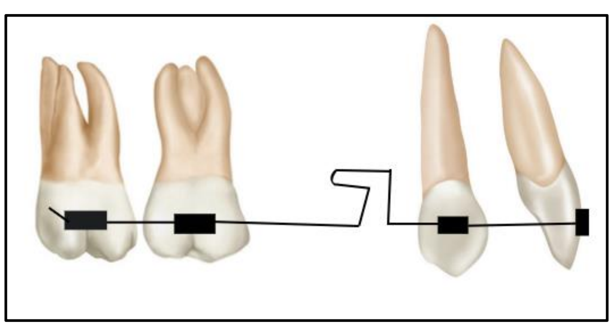


Figure 2: Reverse L loop.[8]

A centered T-loop's force mechanism was comparable to that of the reverse L-loop. Using reverse L loop, with the decrease in interbracket distance the M/F ratio at the canine bracket was decreasing with an increase in M/F ratio at the posterior side. Increasing the loop dimensions from 8 to 10 mm increased the M/F ratio, simultaneously maintaining the intrusive force at the canine bracket. The M/F ratios on the PB end consistently exceeded those on the CB end across all interbracket distances. While the reversed L-loops did not achieve M/F ratios as high as 8–10 on either side, they still maintained relatively high and stable ratios, ensuring controlled tipping.

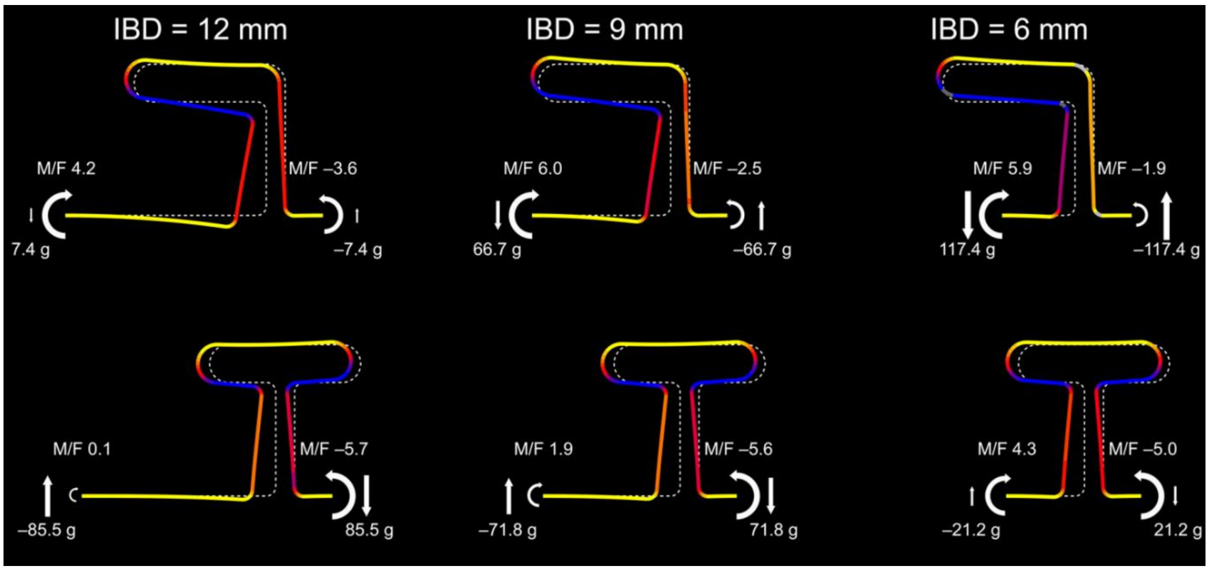


Figure 3: Reversed L loop – With an increase in interbracket distance the intrusive force increases whilst the M/F ratio decreases at the canine bracket.[8]

Initially, Michael Marcotte recommended a 0.016" stainless steel wire, which essentially functions as a closed vertical loop spring called the Marcotte spring (Figure 4). Davis et al., adapted this spring design by using a 0.017 × 0.025" titanium molybdenum alloy (TMA) arch wire extended from the auxiliary tube of the first molar to the cuspid. The choice of 0.017 × 0.025" TMA wire was based on its better fit within the auxiliary tube, which had internal dimensions of 0.018 × 0.025". This adjustment was aimed at improving rotational and directional control.[9]

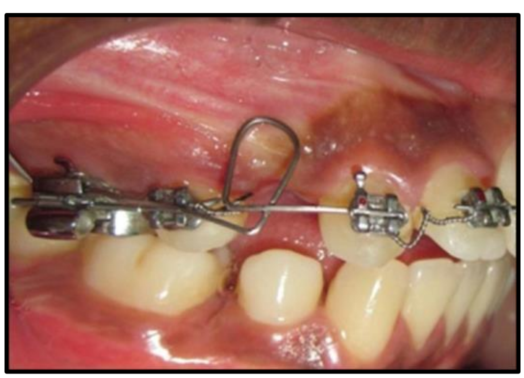


Figure 4: Modified Marcotte Spring.[9]

The loop design comprised a closing loop with a width of 3 mm and a height of 6–8 mm. The height between the mesial and distal arms was set at 2 mm. Anti-rotation bends of 10°–15° were applied to the mesial arm, along with a mesial tip of 15°–20°. Additionally, anti-extrusion bends of 20°–30° were incorporated into the distal arm. On comparing the effectiveness of modified Marcotte (MS) and T-loop (TLS) retraction springs for canine retraction using a split-mouth design, MS showed higher retraction rates and better rotation control but resulted in more tipping and anchorage loss compared to TLS. TLS caused more discomfort according to visual analog scale scores.[9]

2. **Dual force canine retractor**

   The dual-force canine retractor (Figure 5) is fabricated by selecting preformed bands for molars and attaching triple tubes with a 0.018-inch slot (Roth) on the buccal aspect in a conventional manner. Bands are also prepared for the cuspids. Once seated, the bands are transferred to a cast using alginate impression material to obtain a working model. Power arms, consisting of six equal-length (10 mm) segments with built-in hooks made from 0.017 × 0.025 stainless steel wire, are then prepared. Four of these are arranged in a ribbon-arch mode for the palatal and buccal aspects of the cuspid, while two are designed for insertion into the auxiliary tube of the molar in an edgewise mode, with a transverse offset to prevent gingival impingement. A Transpalatal Arch (TPA) with a central omega loop and bilateral distally directed hooks at the level of the palatal power arm of the cuspid is also prepared. The TPA and power arms of the cuspids are then affixed to the working model for soldering, with an acrylic button added to the TPA for additional anchorage support. The appliance is then finished, polished, and cold sterilized. This results in a "three-piece" appliance—a single unit for molar and one each for two cuspids. After cementing the appliance using glass-ionomer cement, the power arm is placed into the auxiliary tube of the molar from the mesial to the distal and cinched. Elastic chains are engaged from the hooks of the power arms of the cuspid to the molar on the buccal aspect, and from the hooks of the TPA to the power arm of the cuspid on the palatal aspect to aid orthodontic tooth movement. Nandan et al, aimed to compare the T-loop segmental arch with the dual-force cuspid retractor and concluded that the dual-force cuspid retractor significantly reduced the canine retraction time compared to the T-loop method. Less anchorage loss, rotation, and tipping were the additional advantages offered by the dual-force canine retractor.[10]

Figure 5: Dual Force canine retractor.[10]

3. **Ladanyi/Remaloy Spring design (Figure 6):** Ladanyi created a ready-made sectional archwire for canine retraction that modifies the closed helical vertical loop by using Blue Elgiloy wire measuring 0.016 x 0.022 inches.

Figure 6: Ladanyi/Remaloy Spring.[11]

Ozkan and Bayram compared the effectiveness of Ladanyi spring (commercially marketed by Dentarum) and reverse closing loop in patients needing first premolar extractions and maximum anchorage in the maxilla. Evaluation using cephalometric films and orthodontic models showed both systems to be effective in canine retraction and providing maximum anchorage, with no significant differences among them. They concluded that both systems can be used effectively for segmental retraction of canines with little anchorage loss.[11]

4. **S-TAR spring:** The spring design proposed by Jain et al. is simple to create and activate during a chairside procedure, allowing for either simultaneous or sequential movement in three-dimensional space. The S-TAR (simultaneous torquing, aligning, and retraction) spring (Figure 7) was created with the purpose of preserving the torque of the canine while also facilitating its retraction and extrusion into the extraction space. A 9 mm closing loop is formed in the wire, maintaining a 2 mm distance between its legs, aiding in canine retraction.[12]

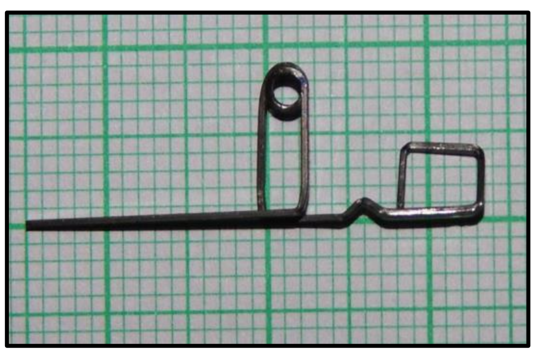


Figure 7: S-TAR spring.[12]

A V bend is made just distal to the canine to localize torque to the anterior part of the wire. A 3-4 mm high box is created anterior to the V bend, near the bracket of the canine, to assist in torquing the tooth and maintaining its tip and torque during retraction. Sufficient wire is left posteriorly to enter the auxiliary tube on the molar band. Before inserting the spring, a 15° preactivation lingual root torque is applied anterior to the V bend. Final activation of the spring is achieved by activating the closing loop by 2 mm.[12]

5. **3-D canine loop (Figure 8):** The fabrication of a three-dimensional canine loop according to Mehrotra et al., involves the following steps:

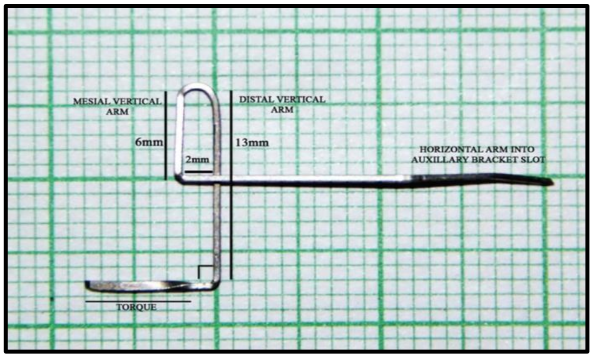


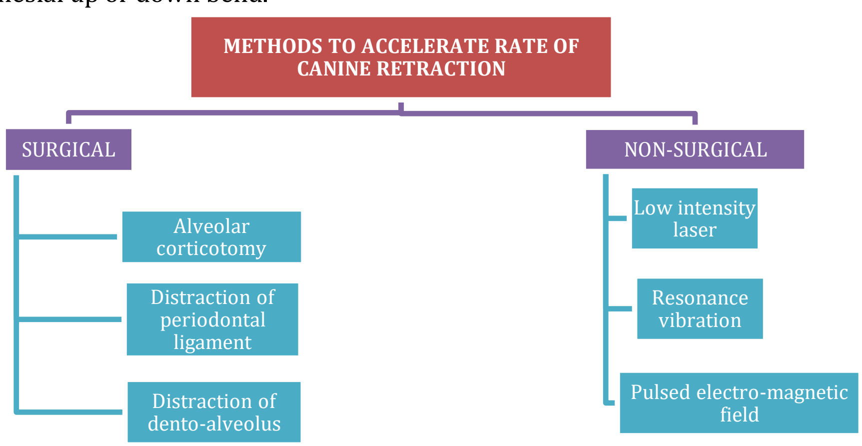
Figure 8: 3-D canine loop.[13]

To alleviate patient discomfort, the bracket is bonded on the palatal side of the buccally placed canine. A 0.017" × 0.025" TMA wire is bent to form a closed loop with a mesial vertical arm of 6 mm and a distal vertical arm of 13 mm. The loop legs are separated by 2 mm. The longer distal arm helps in extruding the highly placed canine into the arch, and its height can be adjusted as required. The distal arm is curved toward the tissue surface to facilitate implantation over the palatally positioned cuspid bracket.

- To form an active arm, the distal vertical arm is bent 90° to contact the slot of the palatally bonded cuspid bracket. Preactivation palatal root torque of 15° is used to keep the roots in cancellous bone and prevent cortical anchoring or dehiscence during labial cuspid movement.
- To rectify angulation of labially positioned cuspids, the active arm can be given a 15° mesial up or down bend.
- The mesial vertical arm is bent 90 degrees distally to adjust into the auxiliary slot of the molar tube.
- The 3D canine loop is successfully placed in a patient with an ectopically positioned canine, giving positive outcomes.[13]

New Methods Introduced to Accelerate Rate of Canine Retraction

A wide range of novel techniques have been introduced to accelerate orthodontic canine retraction. These techniques can be generally divided as surgical and non-surgical. Non-surgical techniques that have been studied are low-intensity laser irradiation, Resonance vibration, pulsed electromagnetic field, electrical currents, and pharmacological approaches. The surgical category comprises of alveolar corticotomy, distraction of the periodontal ligament and distraction of the dento-alveolus.[14]



Methods to accelerate the rate of canine retraction.[14]

1. **Traditional Corticotomy facilitated methods:** Corticotomy or decortication implies to the intentional cutting of cortical bone. It has been claimed that the technique dramatically shortens treatment time by eliminating dense cortical bone resistance to orthodontic tooth movement. This diminished resistance was explained by the underlying regional acceleration phenomenon (RAP) occurring after a wound. RAP involves the recruitment of osteoclasts and osteoblasts at the injured site for wound healing, resulting in a transient localized phenomenon of demineralization/remineralization in the bony alveolar enclosure.

Raza et al. assessed the effectiveness of corticotomy-facilitated orthodontics in facilitating rapid canine retraction in a split-mouth single-centered, parallel-group, randomised clinical trial. The corticotomy group's mean time for complete canine retraction was 5.7 months, while the control group's was 7.1 months. In the control group, the mean root resorption was 0.53 mm, while in the corticotomy group, it was 0.24 mm. Generally, corticotomy resulted in less root resorption, quicker initial canine retraction, and higher initial pain perception; however, after a week, these effects decreased to levels similar to those of conventional methods.[15]

- **Flapless Laser Corticotomy:** A novel method has been under consideration for accelerating retraction rates without the need of a flap surgery. A controlled trial by Jaber et al. compared the effectiveness of laser-assisted flapless corticotomy with traditional methods in speeding up canine retraction and assessed levels of pain and discomfort following the procedure. The randomised controlled trial used a split-mouth design and was conducted on eighteen class II division 1 patients who required the extraction of the first upper premolar followed by canine retraction. Up until the eighth week, there were significant differences in the canine retraction rates between the experimental and control groups; however, no significant differences were seen between weeks eight and twelve. At different assessment times, there was a significant decrease in pain during eating when compared to the baseline. Therefore, it seemed that Er: YAG laser-assisted flapless corticotomy could expedite canine retraction with only minimal pain and discomfort.[16]
- **Piezocision:** The effectiveness of piezocision and corticotomy was evaluated in a systematic review by Viwattanatipa and Charnchairerk which reported that both the rate of tooth movement and the cumulative tooth movement for piezocision were twice as fast as those of the traditional technique. Periodontal health was not negatively impacted by flapless piezocision or corticotomy (with a flap design that avoids marginal bone incision). However, patient satisfaction was higher following piezocision. The scarcity of primary research publications on both techniques constituted the primary limitation of this investigation. The rate of canine movement following piezocision for canine retraction into the immediate premolar extraction site was nearly identical to that of corticotomy with only buccal flap elevation.[17]

2. **Distraction-assisted canine distalization**

The individual canine distractor (Figures 9 and 10) is a tooth-borne, semirigid device which was designed by Dr Bengi. After the selection of bands for the canines and first molars, the bands were transferred into the impression material, and the study model is obtained. Conventional palatal tubes are soldered on the buccal surface canine and molar bands, perpendicular to each other. The device consists of an anterior part, a posterior part, a screw, and a hex wrench to advance the screw. The sections of the distractor are derived from a conventional Hyrax screw, and the tips of the sections are made rectangular to adjust in the tubes.

The posterior portion includes a round sliding rod (1.5 mm), a retention arm (with a rectangular tip) for the first molar tube, and a grooved screw socket. The anterior portion includes a retention arm for the canine tube and two non-grooved slots for the sliding rod and screw. The screw (2.5 mm) and the hex wrench are made up of stainless steel. The top of the screw is thicker than the grooved part, rectangular in shape to allow patient activation of the screw with the hex wrench. Because the distractor is unilateral, a 360^0 activation of the screw produced 0.5 mm of distalization of the canine. The length of the screw is arranged according to the distance between the distal aspect of the canine and the mesial aspect of the first molar.[18]

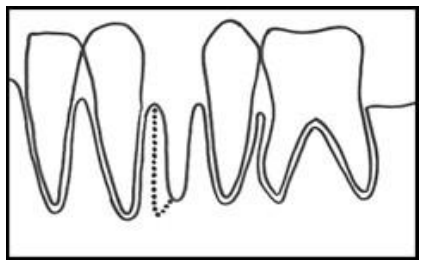


Figure 9: Vertical and oblique osteotomies (dotted) to alleviate interseptal bone resistance.[19]

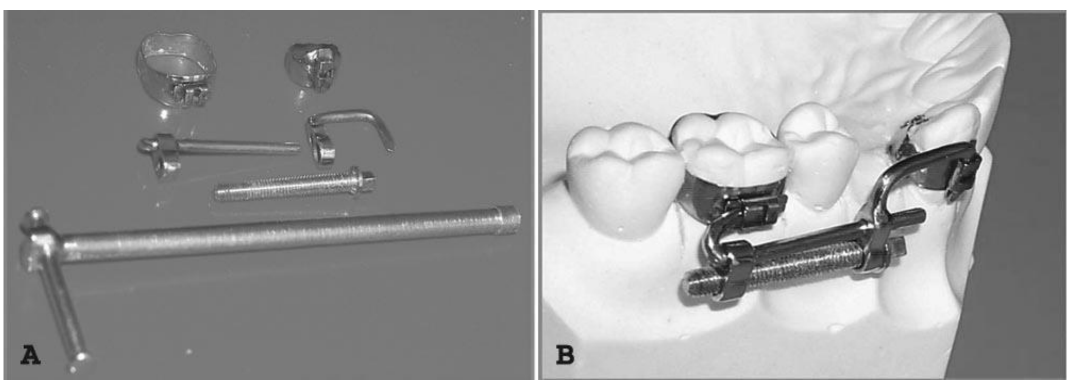


Figure 10: Distraction assisted canine distalization.[19]

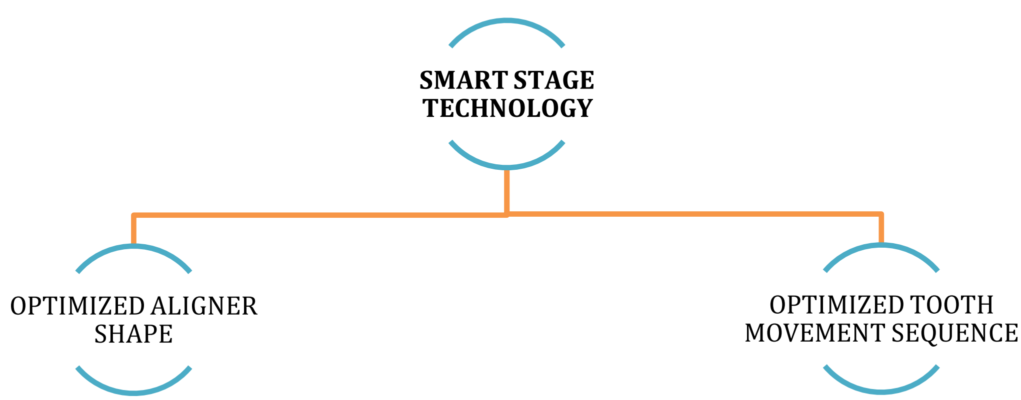
3. **Low-Intensity Laser Therapy:** One of the non-invasive surgical methods used in the field of accelerated orthodontics is low-intensity laser therapy (LILT). Low-level laser therapy (LLLT) has been shown to have anti-inflammatory, biostimulation, and quicker healing effects than bleeding. Most studies indicate that it quickens tooth movement, which shortens the time needed to complete braces. It is easy to use, secure, and barely noticeable.

   Notwithstanding these pieces of evidence, research on low-level laser therapy has produced inconsistent results. In a split-mouth study by Kharat et al.,[17] compared to conventional canine retraction, it was found that the rate of canine retraction increases when combined with LLLT-assisted accelerated orthodontics. Even though LLLT doesn't relieve pain right away, it does so between 24 and 72 hours later.[19]

4. **Autologous Leukocyte -Platelet Rich Fibrin (L-PRF):** Autologous L-PRF was found to accelerate the rapidity of maxillary canine retraction over an 8-week period, albeit only by 0.35mm, in a randomized controlled trial examining the effect of L-PRF on the retraction rate. This slight acceleration mostly occurred within the first four weeks. The same investigation also found that the experimental group's levels of IL-β and TNF-α were significantly higher than that of the control group. This finding is in agreement with a study conducted by Krishna V et al in which the L-PRF accelerated the rate of maxillary canine retraction by 0.28 mm over an 8-week period. A systematic review and meta-analysis by Jitendra Sharan et al concluded that platelet-rich fibrin enhances the orthodontic tooth movement rate, but the evidence quality was moderate.[20]
5. **Vibrations to accelerate tooth movement:** In a systematic review conducted by Jing et al, out of 8 clinical trials, four studies found that vibration did not accelerate the Orthodontic Tooth Movement during the alignment phase. Two studies revealed that the use of vibratory stimulation accelerated canine retraction. Hence, he concluded that the vibrational stimulus is effective for accelerating canine retraction but not for alignment. Pavlin et al. reported the average rate of maxillary canine retraction was significantly increased using an AcceleDent device for 20 min per day (0.86–1.45 mm/month vs 0.49– 1.09 mm/month).[21]
6. **Effect of low-intensity static magnetic field (SMF) in accelerating tooth movement:** Neodymium-iron-boron magnets have been suggested as a contemporary method for accelerating the process of orthodontic tooth movement (OTM). However, only a limited number of clinical trials have been performed to date. A split-mouth clinical trial comparing the retraction rate of stainless-steel coil springs and neodymium iron-born magnets has concluded that the low-intensity static magnetic field was effective at accelerating upper canine retraction but was not clinically significant.[22] An animal study conducted by Sakata et al has also observed an acceleration of tooth movement with the application of SMF particularly during the early period.

Developments in Clear Aligners

In 2015, Invisalign introduced G6 and Smart Stage to improve aligner performance for the first premolar extraction treatment. The first application is to change the geometry of an aligner, while the second is to change the order of tooth movement. A cautious application of the procedure prevents undesired tilting and anterior extrusion of incisors during retraction.



Distal incisor tipping and buccal segment mesial tipping are two common adverse effects of closing the first premolar extraction spaces. Clinicians can lessen these adverse effects with fixed appliances by making archwire changes such as Spee curves, and gable bends, or using a full-size rectangular archwire. Clear aligners can replicate similar effects if they are intended to change form or shape. (Figure 11) These aligner activations, together with improved attachments, effectively close the extraction space.[23]

Smart Stage technology is intended to improve aligner form and tooth movement progress, resulting in more predictable clinical outcomes. To preserve posterior anchoring, a two-step anterior retraction approach is recommended in place of en masse space closure. Canines are retracted about one-third of the extraction gap, and all six interiors are retracted later using posterior arch anchorage. SmartStage adapted this simplified two-step anterior retraction procedure, although not all clinicians believe it is useful or efficient.[23] (Figure 12)

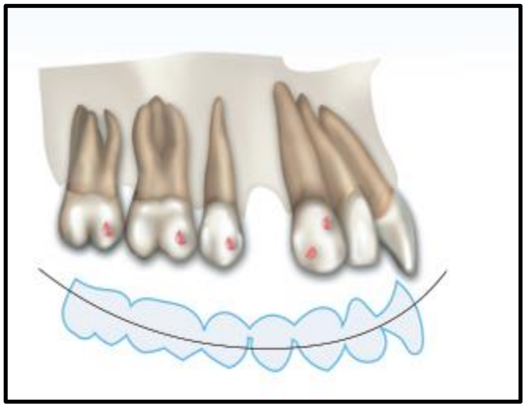


Figure 11: Optimized aligner shape.[23]

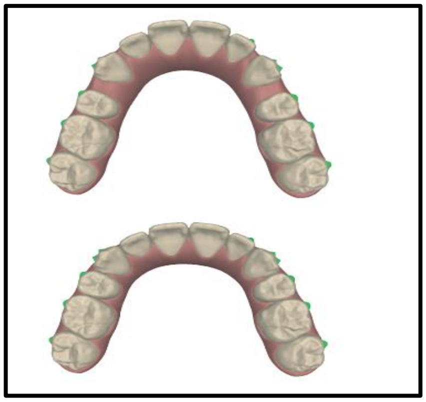


Figure 12: Optimized tooth movement sequence.[23]

Conclusion

In conclusion, recent advances in canine retraction techniques have showcased innovative approaches aimed at enhancing efficiency, reducing treatment duration, and improving patient comfort during orthodontic treatment. As research continues to push the boundaries of orthodontic innovation, the future holds exciting possibilities for further refinement and implementation of these techniques, ultimately contributing to enhanced treatment experiences and outcomes for individuals undergoing orthodontic therapy.

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