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Comparative evaluation of the efficiency of canine retraction using modified marcotte and opus loop – A split mouth, randomized clinical trial

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ABSTRACT

Aim: To Compare the efficiency of canine retraction using modified Marcotte and Opus loop.
Materials and Methods: Patients with all first premolar extraction were fitted with Opus and Modified Marcotte loop on left and right side of maxillary arch. Rate of canine retraction was evaluated after 3-months using digital Vernier Callipers on procured models, Lateral cephalograms, and OPG.
Results: Average retraction with Modified Marcotte loop using TMA wire was 2.5±0.5 mm and Opus Loop using TMA wire was 3.8±0.5mm for the period of three months. Average retraction with Modified Marcotte loop using TMA wire was 1.1 mm and Opus Loop using TMA wire was 0.77 mm for the period of three months.
Conclusion: Greater amount of maxillary canine retraction occurred using the 0.017 × 0.025 TMA Opus loop (3.8 mm) as compared to the 0.017 × 0.025 TMA Modified Marcotte loop (2.5 mm).The anchorage loss with Modified Marcotte loop is more (1.1mm) compared to Opus loop (0.07mm). The 0.017 × 0.025 TMA Modified marcotte loop showed 15.75° tipping, whereas the 0.017 × 0.025 TMA Opus loop showed 6.75° tipping, indicating that the Opus loop had better control.

1. Introduction

Orthodontic treatment for the patient with dentoalveolar protrusion usually requires extraction of four premolars, followed by retraction of the anterior teeth into the extraction space thereby relieving the protrusion.

The retraction of the anterior teeth can be done with either of the mechanics.

1. Frictionless mechanics.
2. Friction or sliding mechanics.

Frictionless mechanics involve the use of orthodontic loops such as Omega loop, tear drop loop etc.

Friction mechanics involve the use of elastic chain, NiTi coil spring, e-tie etc.

1.1. Two school of thought of retraction: [1,2]

The first school of thought states that canines and incisors are retracted separately to converse anchorage in sliding mechanics. The principle is by retracting fewer teeth at a time, less stress is placed on the posterior anchorage. Moreover, by adding teeth to the posterior segment one can enhance the anchorage because when teeth are added, the forces are distributed over a large root surface area, making individual posterior teeth less likely to move anteriorly.

The second school of thought is En-masse retraction, where the canines and incisors are retracted together. Here, the method of anchorage is based on the types of tooth

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movement in the posterior and anterior segment and does not entirely depend on the number of teeth in each segment.

The preadjusted edgewise system of today, utilizes different retraction modalities. The major disadvantages of using stainless steel ligatures for space closure is that their force dissipates almost immediately, requiring frequent activation. Elastic chain demonstrates permanent deformation and consequent force degradation in shorter time period.[3]

Many loop designs are used in canine retraction which has been studied and their suitability & efficacy has been tested, which has led to better understanding of biomechanics of canine retraction. Titanium molybdenum alloy (TMA) and stainless steel (SS) are the most commonly used wires for making loops.

A single closing loop design using 0.016" SS wire has been described by Michael Marcotte. He has recommended its use for minor cuspid retractions. The design of this spring is very simple and may be fabricated at the chairside.[4]

Opus loop has been described by Raymond E Siatkwoski in 1997. This delivers a M/F ratio in the range 8.0-9.0mm,with good allowable working load & low deflection rate.[5]

In this study, Comparison is done to evaluate the effeciency of canine retraction with Modified Marcotte and Opus loop.

1. Amount of retraction achieved after 3 months is measured using a study model.
2. Amount of anchorage loss measured using study model.
3. To evaluate the effectiveness of bodily movement of canine.

2. Materials and Methods

This prospective in vivo study was conducted at the Department of Orthodontics and Dentofacial Orthopaedics, Thai Moogambigai Dental College and Hospital, Chennai, India and was approved by the Institutional Ethical Clearance Committee. Ten maxillary canine retraction patients were selected on the basis of the following criteria:

2.1. Inclusion criteria

1. Age 18- 35 years
2. Minimal or no crowding
3. Teeth without any pathological findings
4. 1^{st} premolar extraction cases
5. Space min 4mm distal to canine
6. Low/ average angle cases
7. Low/ average anchorage
8. After leveling and aligning
9. Absence of crowding

2.2. Exclusion criteria

1. Medically compromised patients
2. Periodontally compromised 3. Severe crowded teeth
3. High angle cases
4. High anchorage cases
5. Missing molars

Ten patients in the age group range 18-35 years scheduled for orthodontic treatment with first premolar extraction and with space 4mm distal to canine requiring two-step retraction was selected for this study. (Figure 1)

The entire procedure was explained to the patient and their parents and the study commenced only after acquiring due consent from the patients and patient's parents.

2.3. Evaluation of the patients

All patients were examined clinically with the following records. The following pre-retraction records were obtained from each patient.

1. Panoramic radiograph with reference markers
2. Lateral cephalograms with reference markers
3. Standard photographs (Intra oral)
4. Study models.

2.4. Preparation

Following extraction of first premolars, initial leveling was performed with the preadjusted edgewise appliance (MBT prescription, 0.022 × 0.028" slot, Ormco). All patients were group B anchorage cases, addressed with the use of transpalatal arches. Initial leveling and alignment commenced with 0.014" round NiTi wire in all cases and progressed according to common MBT treatment sequence. The maxillary dentition was aligned and leveled, and canines uprighted using 0.016 × 0.022 inch NiTi wire prior to placement of the 0.016 × 0.022 inch stainless steel customized continuous base archwire. (Figure 2)

2.5. Fabrication of the reference marker

To measure the angulation changes in the canines during retraction, 10 stainless steel wire jigs with triangular ends for left canine (0.017 × 0.025 inch rectangular stainless steel) and round ends for right canine (0.017 × 0.025 inch rectangular stainless steel) respectively were fabricated. Stainless steel jigs were placed in between the tie wings of the canine brackets (triangular jig in the left and round jig in the right canine bracket respectively) and secured into place using ligature ties. (Figure 3)

2.6. Fabrication of loop

The Modified Marcotte loop were fabricated of 0.017 × 0.025 inch TMA wire for right maxillary canine and Opus

Loop were fabricated of 0.017 × 0.025 inch TMA wire for left maxillary canine. The Loops were placed in the center of the 1st premolar extraction spaces.

Canine retraction spring with a single closing loop design using 0.016" SS wire has been described by Michael Marcotte. He has recommended its use for minor cuspid retractions. The design of this spring is very simple and may be fabricated at the chairside. It is fundamentally a closed vertical loop spring. This spring design has been modified by us to the extent of using a 0.017 × 0.025" TMA arch wire extended from the auxiliary tube of the first molar to the cuspid. The rationale of using 0.017 × 0.025" TMA wire is that it would give a better fit in the auxiliary tube which has a 0.018 × 0.025" internal dimension. This would give better rotational and directional control. The loop design consisted of a closing loop of 3 mm width and 6–8 mm height. The height between mesial and distal arm was kept at 2 mm.[6] (Figure 4). Opus loop described by Raymond E. Siatkowski. The dimensions of the standard Opus 70 loop are shown in (Figure 5).

2.7. Standardization of Force

Force of 150g was applied every visit at 4 weeks interval (Figure 6)

Before canine retraction and after 3 months of retraction period, the following records were taken for each patient.

1. Lateral cephalogram and OPG with reference markers.
2. Standard photograph (Intraoral) (Figure 7).
3. Study model – every month for three months of retraction period.

2.8. Study model analysis

Pre-retraction and post-retraction study model were analyzed and compared to evaluate the amount of canine retraction and anchorage loss.[7]

2.9. Standardization for obtaining measurements

To measure the movement of canine and molar, an acrylic palatal plug was made on maxillary arch. This plug was fabricated from acrylic with reference wires (0.019×0.025-inch stainless steel) embedded in the acrylic that extended to the cusp tip of canine and to the central fossa of the first molar. The initial model (T0) was used to make the plug, which was then fitted to the models taken every 4- weeks interval during retraction of both canines.(Figure 8)

2.10. Dental casts assesment amount of canine retraction

The rate of retraction was calculated as the distance traveled divided by the time required to complete space closure. This was recorded in millimeter per interval. An interval was defined as a 4- weeks period. Patients were seen at 4- weeks interval until retraction was completed.

Measurements were performed by direct technique from stone casts obtained before and after 3 months of retraction. Vernier caliper was used to measure the maximum distance between the cusp tip of the canine and the reference wire placed on the tip of the canine before retraction at the end of every interval. The difference between the initial and 4- week interval measurements for 3 months was calculated to obtain the total amount of retraction. This measurement was repeated three times and the mean value was taken.(Figure 9)

2.11. Anchorage loss

Anchorage loss was recorded as the amount of movement in millimeters that occurred in the direction opposite to the direction of the applied resistance. Direct cast measurements were used rather than radiographs. This method was considered to be easier and accurate, and did not subject patients to excessive radiation exposure. Digital vernier caliper was used to measure the anchor loss from the central fossa of the molar to the tip of the wire originally placed. This super-imposition allowed for the direct observation of amount of molar protraction (anchorage loss) (Figure 10).

2.12. Evaluation of canine angulation from OPG

Canine angulation was assessed from OPG. Infraorbital plane was traced on the orthopantomogram and a long axis of the Canine angulation was assessed from OPG. Infraorbital plane was traced on the orthopantomogram and a long axis of the Canine angulation was assessed from OPG. Infraorbital plane was traced on the orthopantomogram and a long axis of the Canine angulation was assessed from OPG. Infra-orbital plane was traced on the orthopantomogram and a long axis of the tooth is drawn. The angle between these two lines was measured on both pre-retraction and post-retraction orthopantomogram. Pre-treatment and Post- treatment values were compared to their respective sides.[8]

Result was evaluated based on the pre retraction and post retraction radiographic and study model analysis findings.

2.13. Determination of amount of retraction- based on study model analysis

Average retraction with Modified Marcotte loop using TMA wire was 2.5±0.5 mm and Opus Loop using TMA wire was 3.8±0.5mm for the period of three months.

2.14. Determination of anchorage loss - based on study model analysis

Average retraction with Modified Marcotte loop using TMA wire was 1.1 mm and Opus Loop using TMA wire was 0.77 mm for the period of three months.

2.15. Angular changes in canine before and after retraction – based on orthopantamogram

Average angular change (Tipping) with T-Loop using TMA wire was 7 mm and T- Loop using stainless steel wire was 10 mm for the period of three months.

2.16. Statistical analysis

Table 1 shows the amount of canine retraction,Since the p value is <0.001, there is statistically significant difference in amount of retraction when compared with different loop types. When comparing the mean values it states that Opus loop (3.86 +/- 0.18) exerts greater retraction than Modified marcotte loop (2.55 +/- 0.13).

Table 2 shows the amount of anchorage loss, Since p value is <0.001, there is statiscally significant difference in loss of anchorage when compared within the loop types. When comparing the mean values, modified marcotte loop(1.10, +/-0.08) shows more loss of anchorage than opus loop(0.77,+/-0.08).

Table 3 shows angular changes in canine before and after retraction – based on orthopantamogram**,** Since p value is <0.001, there is statiscally significant difference in canine angulation when compared within the loop types. When comparing the mean values, modified marcotte loop (15.75, +/-0.54) shows more angular changes than opus loop (6.75,+/-0.42).

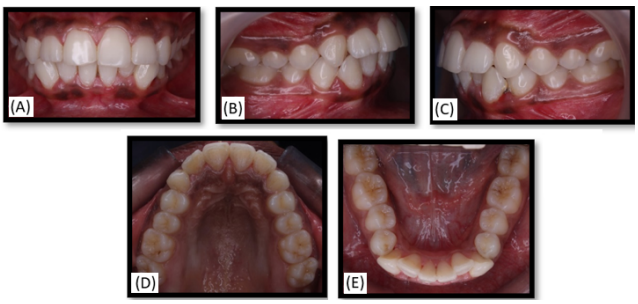

Figure 1: Pre-operative: **A:** Centre; **B:** Right lateral; **C:** Left lateral; **D:** Maxillary arch; **E:** Mandibular arch

The primary goal of an orthodontic treatment is to improve the quality of patient's life through enhancement of dentofacial functions and esthetics. Orthodontic therapy depends on the biological response to the orthodontic forces. Orthodontic tooth movement is a process in which a mechanical force is applied to induce alveolar bone resorption on the pressure side, and alveolar bone deposition

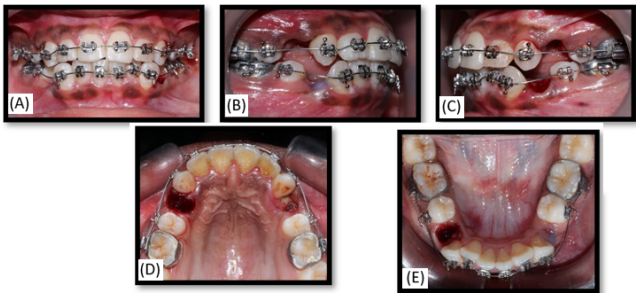

Figure 2: Strap-up: **A:** Centre; **B:** Right lateral; **C:** Left lateral; **D:** Maxillary arch; **E:** Mandibular arch

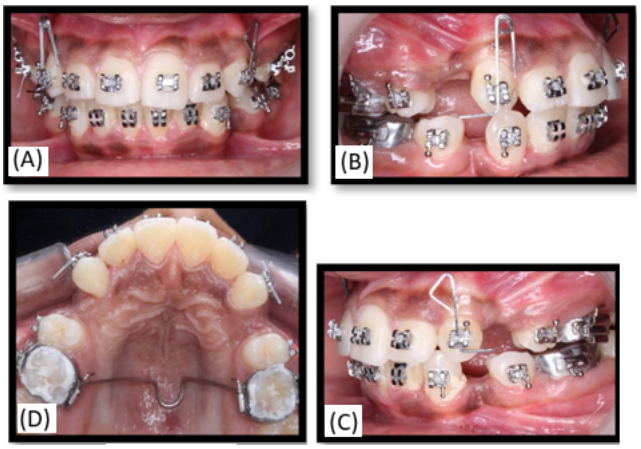

Figure 3: Fabrication of markers:**A:** Centre; **B:** Right lateral; **C:** Left lateral; **D:** Maxillary arch

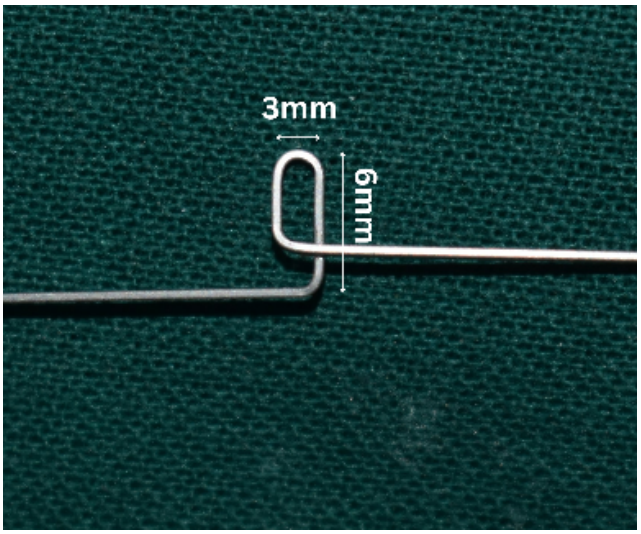

Figure 4: Modified marcotte loop

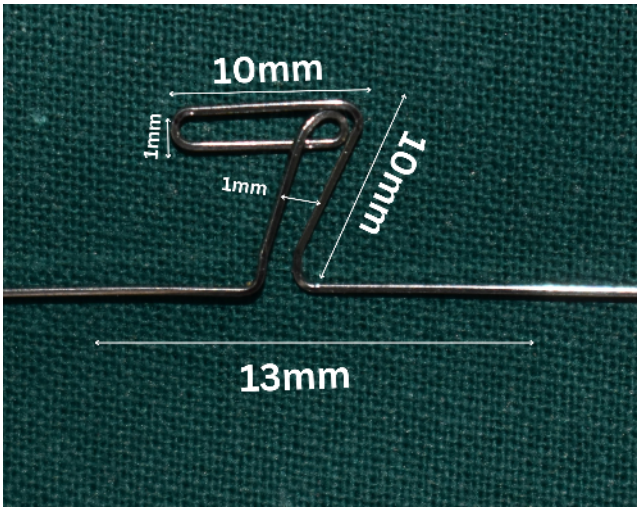

Figure 5: Opus loop

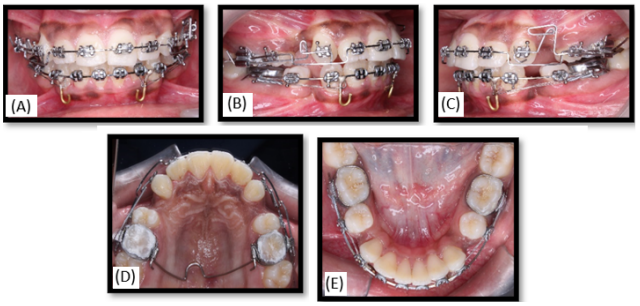

Figure 6: Retraction initial phase: **A:** Centre; **B:** Right lateral; **C:** Left lateral; **D:** Maxillary arch; **E:** Mandibular arch

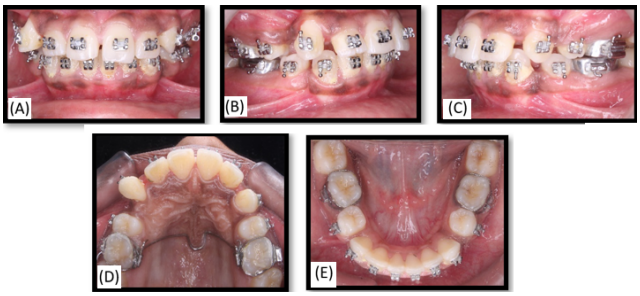

Figure 7: 3 month Post-retraction: **A:** Centre; **B:** Right lateral; **C:** Left lateral; **D:** Maxillary arch; **E:** Mandibular arch

on the tension side.[9]

In most orthodontic patients, including those with severe skeletal disharmonies, esthetic improvement is a primary treatment objective. In such cases, extraction of premolar teeth and the labial segment retraction is generally indicated when there is obvious protrusion. The retraction is considered as the critical part of treatment and should be precisely controlled.[9]

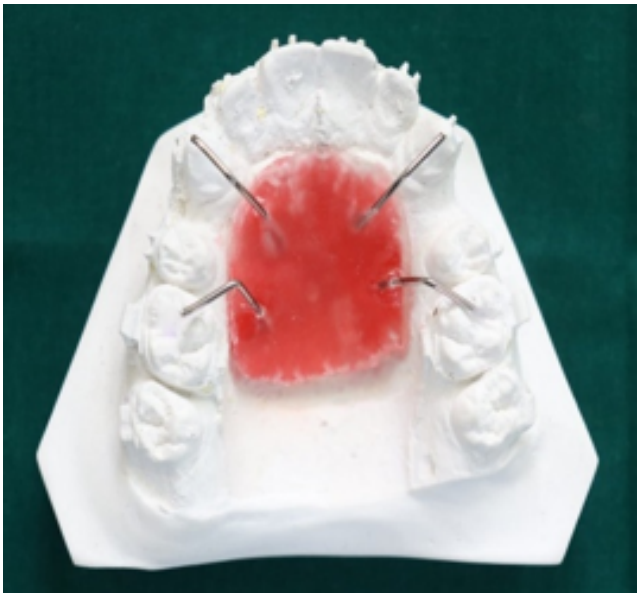

Figure 8: standardization for obtaining measurements

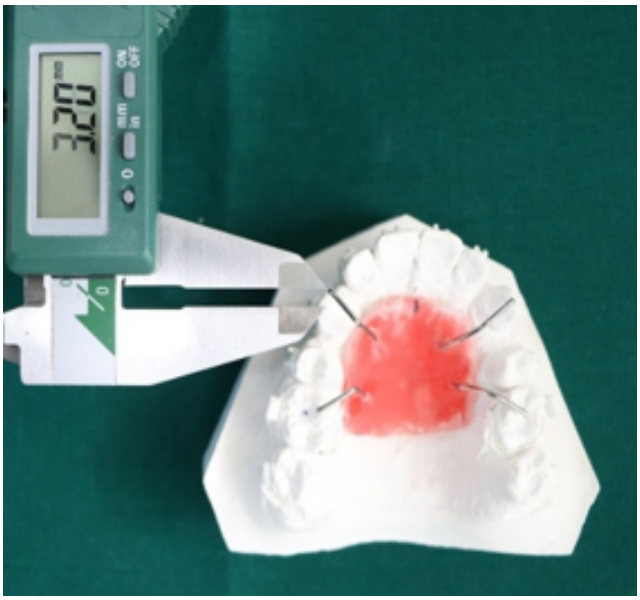

Figure 9: Amount of retraction

Physiologically, rates of movement are indirect indicators of bone turnover and remodeling. The tooth first shows an immediate slight movement, followed by a lag phase associated with phase of constant movement.[10]

Wasaki et al[11] detected the lag phase when low force and high movements were applied to the canine, suggesting an even stress distribution to the root surface. Precise control over the centre of rotation of teeth and the biologic response during the space closure regardless of the appliance used, requires an optimal force system along with a line of force application. Our understanding is these force characteristics

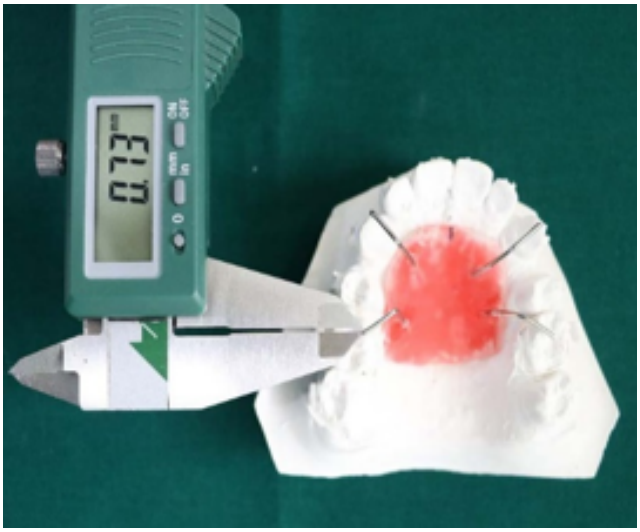

Figure 10: Anchorage loss

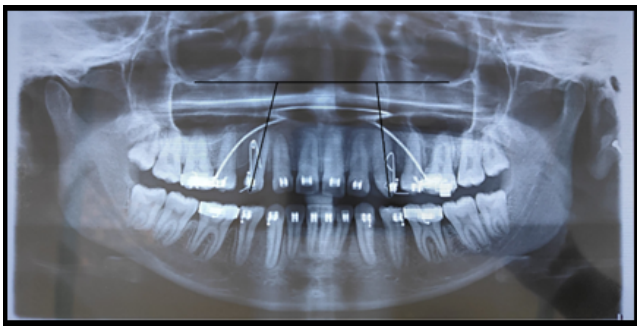

Figure 11: Evaluation of canine angulation from

Table 1:

Patient No	Loop	Maxilla
1	Opus Loop	3.7 mm
	Modified Marcotte	2.6 mm
2	Opus Loop	4.0 mm
	Modified Marcotte	2.7 mm
3	Opus Loop	4.0 mm
	Modified Marcotte	2.5 mm
4	Opus Loop	3.9 mm
	Modified Marcotte	2.7 mm
5	Opus Loop	3.8 mm
	Modified Marcotte	2.4 mm
6	Opus Loop	3.5 mm
	Modified Marcotte	2.6 mm
7	Opus Loop	3.7 mm
	Modified Marcotte	2.4 mm
8	Opus Loop	3.9 mm
	Modified Marcotte	2.5 mm
9	Opus Loop	4.0 mm
	Modified Marcotte	2.7 mm
10	Opus Loop	4.1 mm
	Modified Marcotte	2.4 mm

Table 2:

Patient No	Loop	Maxilla
1	Opus Loop	0.7 mm
	Modified Marcotte	1.0 mm
2	Opus Loop	0.8 mm
	Modified Marcotte	1.1 mm
3	Opus Loop	0.7 mm
	Modified Marcotte	1.0 mm
4	Opus Loop	0.9 mm
	Modified Marcotte	1.2 mm
5	Opus Loop	0.8 mm
	Modified Marcotte	1.1 mm
6	Opus Loop	0.8 mm
	Modified Marcotte	1.0 mm
7	Opus Loop	0.7 mm
	Modified Marcotte	1.2 mm
8	Opus Loop	0.9 mm
	Modified Marcotte	1.1 mm
9	Opus Loop	0.7 mm
	Modified Marcotte	1.1 mm
10	Opus Loop	0.7 mm
	Modified Marcotte	1.2 mm

Table 3:

Patient no	Loop	Pre-Retraction (degree)	Post-Retraction (degree)	Angular change (degree)
1	Opus Loop	86°	93°	7°
	Modified Marcotte	87°	102°	15°
2	Opus Loop	87°	93.5°	6.5°
	Modified Marcotte	80°	96°	16°
3	Opus Loop	87°	93.5°	6.5°
	Modified Marcotte	80°	95.5°	15.5°
4	Opus Loop	87°	94°	7°
	Modified Marcotte	87°	103.5°	16.5°
5	Opus Loop	87°	94°	7°
	Modified Marcotte	87°	103°	16°
6	Opus Loop	86°	92.5°	6.5°
	Modified Marcotte	80°	95.5°	15.5°
7	OPUS LOOP	87°	94°	7°
	Modified Marcotte	87°	102°	15°
8	Opus Loop	86°	93.5°	7.5°
	Modified Marcotte	87°	103.5°	16.5°
9	Opus Loop	86°	92.5°	6.5°
	Modified Marcotte	80°	96°	16°
10	Opus Loop	87°	93°	6°
	Modified Marcotte	86°	101.5°	15.5°

is the key to predictable retraction.

The force system produced by Loop springs depends on many variables, including, wire size and material, spring shape (preactivation shape), spring position, and activation. Controlling the force system produced by an orthodontic appliance or spring is essential to precise tooth movement. Force magnitude, direction, moment-to-force ratio, and force constancy are important variables determined by the orthodontist during treatment.[7]

In this study the mean canine retraction by the Opus loop fabricated with TMA wire was more (3.8mm) as compared with the mean retraction by the Modified Marcotte loop fabricated with TMA wire (2.5 mm). This is because The height of the opus loop being more as compared to Modified Marcotte loop and 70° angulation given to vertical leg contributing to increased M/F ratio.[12] F/D rate generated by opus loop is the lowest due to configuration of the opus loop and 70° angulation given to vertical leg.[13] The anchorage loss with Modified Marcotte loop is more (1.1mm) compared to Opus loop (0.07mm). The difference in anchorage control between Modified Marcotte and Opus loop may be due to the difference in design of the two retraction springs under study Anchorage reinforcement can be done by addition of more teeth in the posterior unit or by incorporating auxiliaries such as transpalatal arch or Nance palatal arch into the anchor unit.[14] It was seen that mean canine tipping by Opus loop was less (6.75°) compared to Modified Marcotte loop (15.75°). This type of more crown tipping than that of the root could be because of inadequate M/F ratio to upright the root along with crown movement or due to inadequate time between activations for root uprighting. Roth et al (1994)[15] recommended separate canine retraction for maximum anchorage extraction cases but did not recommend it for moderate ones.

3. Summary

This prospective clinical study was carried out in the department of orthodontics and dentofacial orthopedics

1. To compare and evaluate the effectiveness and time taken for canine retraction with Modified Marcotte Loop and Opus Loop using split mouth technique.
2. The study objectives included evaluation of the amount of canine retraction, amount of anchorage loss and angular change in three months.
3. Ten patients were selected between an age group of 18- 35 years who were need of orthodontic treatment with first premolar extraction and subsequent canine retraction were selected for this study.
4. Stainless steel jigs were placed in between the tie wings of the canine brackets (Triangular ends for left canine and round ends for right canine) and secured into place using ligature.
5. The loops were fabricated of 0.017 × 0.025 inch TMA wire. The loops were placed in the center of the 1st premolar extraction spaces.
6. The results were evaluated based on the radiographic and study model analysis findings and the patients were evaluated for a period of three months post retraction.
7. In this study the mean canine retraction by the Opus loop fabricated with TMA wire was more (3.8mm) as compared with the mean retraction by the Modified Marcotte loop fabricated with TMA wire (2.5 mm). The anchorage loss with Modified Marcotte loop is more (1.1mm) compared to Opus loop (0.07mm).
8. Angular change (TIPPING) of Canine with Opus loop is less (6.75°) compared to Modified marcotte loop(15.75°).

4. Conclusion

The following conclusions were drawn from the 3-month study:

1. Greater amount of maxillary canine retraction occurred using the 0.017 × 0.025 TMA Opus loop (3.8 mm) as compared to the 0.017 × 0.025 TMA Modified Marcotte loop (2.5 mm).
2. The anchorage loss with Modified Marcotte loop is more (1.1mm) compared to Opus loop (0.07mm).
3. The 0.017 × 0.025 TMA Modified marcotte loop showed 15.75° tipping, whereas the 0.017 × 0.025 TMA Opus loop showed 6.75° tipping, indicating that the Opus loop had better control.

5. Limitations of the Study

1. Different types of malocclusions were not included.
2. Further study with large sample size can be carried out.
3. The increased height of the Opus loop can create problem of tissue impingement and reduce patient compliance.
4. Additional reference planes can be taken.
5. Skeletal malocclusion is not included in the study.
6. Different growth pattern is not included in the study.
7. Amount of retraction and anchorage loss in the mandibular arch was not included in the part of the study.

6. Future of the Study

1. Cone beam computed tomography (CBCT) can be used for better differentiation of right and left side.
2. Cone beam computed tomography (CBCT) can be used for better angulation prediction.
3. Cone beam computer tomography can be used to check the amount of molar tipping and anchorage loss.

4. Amount of retraction in various skeletal malocclusion can be included.
5. Amount of retraction in 5s extraction cases can be done.

7. Source of Funding

None.

8. Conflict of Interest

None.

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