Comparison of the Amount of Maxillary Canine Retraction, with T-Loops, using TMA and Stainless Steel Wires: A Clinical Study

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ABSTRACT

Introduction: The purpose of this study was to evaluate and compare the efficiency between stainless steel and titanium molybdenum alloy (TMA), in terms of canine retraction, canine angulation and canine rotation using identical T-loop design and activation over a 4-month period.

Materials and methods: Fifteen subjects were selected for the study. Standardized T-loops in 0.017 × 0.025 inch TMA and 0.016 × 0.022 inch stainless steel wires for left and right maxillary canines were activated to generate 200 gm of force every month for a period of 4 months.

Results: Greater amount of maxillary canine retraction occurred using the 0.017 × 0.025 TMA T-loop (5.46 mm) as compared to the 0.016 × 0.022 stainless steel T-loop (4.20 mm). The 0.017 × 0.025 TMA T-loop showed 7.83° tipping, whereas the 0.016 × 0.022 stainless steel T-loop showed 10° tipping, indicating that the TMA T-loop had better control. The 0.016 × 0.022 stainless steel T-loop (39.44%) offered better rotational control over the 0.017 × 0.025 TMA T-loop (50.82%).

Conclusion: The 0.017 × 0.025 TMA T-loops offer more canine retraction and tipping control whereas 0.016 × 0.022 stainless steel T-loops offer better rotational control.

Keywords: Canine retraction, Segmented mechanics, T-loops, Titanium molybdenum alloy wire, Stainless steel wire.

INTRODUCTION

The proper position of canines shares a very important role in oral function and esthetics. Their unique position makes their orthodontic movement of great clinical importance, especially in premolar extraction cases. Segmented arch technique is a modified edgewise orthodontic procedure developed by Burstone1 in 1962 which consists of multiple wires found in different portions of arch. The force systems are relatively constant and with long ranges of activation and optimum force levels their resulting movement is predictable, as stated by Burstone, Baldwin, Lawless.2 Later in 1966, Burstone CJ3 stated that moment-to-force ratio, magnitude of force and the constancy of force determine the success of an appliance. The segmented arch technique has many advantages like better control over the forces, more efficient tooth movement over long distances with light constant forces, as stated by Burstone, Koenig (1976).4 In 1980, Burstone and Goldberg5 introduced beta titanium molybdenum alloy (TMA) wire (11% molybdenum, 6% zirconium and 6% beta titanium alloy) which showed twice the amount of deflection and delivered half the amount of force as compared to stainless steel wires. Burstone, van Steenbergen, Hanley6 in 1995 mentioned that T-loops had three important characteristics, i.e. α, i.e. anterior moment or β, i.e. posterior moment and a horizontal moment. 

Viecilli (2006)7 stated that the effects of steps, angles and vertical forces could be combined to produce an ideal T-loop design. According to Proffitt (2007),8 segmented retraction of canines with frictionless springs reduces the strain on posterior teeth and is a readily available approach with the modern 18-slot appliance.

This study was undertaken over a 4-month period at the Department of Orthodontics and Dentofacial Orthopedics, Bharati Vidyapeeth University, Dental College and Hospital, Pune, for the following:

1. To compare the amount of canine retraction using 0.017 × 0.025 TMA and 0.016 × 0.022 stainless steel T-loop springs.
2. To compare the change in canine angulation during canine retraction in both the groups.
3. To compare the effect of 0.017 × 0.025 TMA and 0.016 × 0.022 stainless steel T-loop springs on canine rotation.

MATERIALS AND METHODS

Materials

Fifteen subjects were selected for the study. Following inclusion criteria were used for the selection of subjects in this study:

1. The subjects were in the permanent dentition stage with maxillary 2nd molars erupted.
2. In all subjects, the maxillary 1st premolar on both sides had been extracted for orthodontic treatment.
3. Subjects were already undergoing orthodontic treatment with 0.018 inch MBT preadjusted appliance system. However, canine retraction had not been started.
4. Prior to the study, maxillary dentition of all the subjects were in the alignment and leveling stage.
5. All maxillary canines were aligned. The canines were bilaterally symmetrically placed and upright.

Following stage records were made for all patients:
1. Intraoral photographs at the start (T0) and end (T4) of the study.
2. Linear and angular measurements of right and left maxillary canines using jigs, occlusal splint, digital caliper and protractor at the start (T0), mid (T1, T2, T3) and end (T4) of the study.
3. Lateral cephalograms at the start (T0) and end (T4) of the study.
4. Maxillary arch study models and occlusal photographs of the study models at the start (T0) and end (T4) of the study.

**Preparation**

The four incisors, 2nd premolars and 1st molars were made into one rigid unit by using a 0.016 × 0.022 inch stainless steel customized continuous base archwire. Nance holding arch was used for stabilizing the molars (Fig. 1A). The maxillary dentition was aligned and leveled, and canines uprighted using 0.016 × 0.022 inch NiTi wire (Figs 1B and C) prior to placement of the 0.016 × 0.022 inch stainless steel customized continuous base archwire.

**Fabrication of T-Loop**

The T-loops were fabricated of 0.017 × 0.025 inch TMA wire for left maxillary canine and 0.016 × 0.022 inch stainless steel wire for right maxillary canine (Fig. 2). The T-loops were placed in the center of the 1st premolar extraction spaces.

**Standardization of Force Generated by T-loop Springs**

Reitan (1957) advocated 150 to 250 gm force for continuous bodily movement of maxillary canines. In 1972 Brandt and Burstone stated 150 to 200 gm as a reasonable force value for tipping canines. Ricketts et al (1979) in bioprogressive therapy quoted Lee (1965), who carried out a study on canine retraction and proposed that 200 gm was the optimum force for efficient canine retraction.

Both the T-loops were fabricated in a dental stone assembly and a dial type dynamometer (Somfy Tec, France) and millimetric scale were used to note the amount of force generated on opening of the vertical legs of both the T-loops (Fig. 3). To generate 200 gm of force, the TMA T-loop spring had to be activated by 4 mm and the stainless steel T-loop by 2 mm.

**Preactivation of T-loop Spring**

In the TMA T-loop spring, each preactivation bend was 30°, thus the total of six preactivation bends was 180°. In both the T-loops, antirotation bends of 35° each were placed in the anterior and posterior legs. The antirotation bends were kept
to a minimum to prevent impingement of the T-loops and reduce patient discomfort (Fig. 4).

**Method of Measurement of Linear and Angular Changes in Canines during and after Retraction**

**Indirect Measurements**

To measure the angulation changes in the canines during retraction, stainless steel wire jigs with triangular ends for left canine (0.016 × 0.022 inch rectangular stainless steel) and round ends for right canine (0.6 mm round stainless steel) respectively were fabricated. The jigs were 15 mm in height (Fig. 5). 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 elastomeric modules (Fig. 6).

Lateral cephalograms were made during stages T(0) and T(4). Right and left canines were identified by the shadow of the jigs (Fig. 7). The left and right canine crown angulations were measured at stage T(0) and T(4) by measuring the posteroinferior angles formed by the stainless steel jigs and FH, SN and palatal plane (Fig. 8).

**Direct Measurements**

Intraorally the initial canine position was recorded using angular and linear measurements.

1. Angular measurements were made by orienting the base of the customized protractor assembly (Fig. 9) to the horizontal arm of the customized base archwire and equating the movable stainless steel marker of the protractor to the center of the canine bracket.

2. Customized occlusal splint in acrylic with embedded hooks was used for linear measurement of retracted canines. The 1 mm stainless steel hooks were embedded into the splint corresponding to the distal margin of the
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RESULT AND DISCUSSION

Mean and standard deviations, for the linear and angular intraoral measurements carried out at stages T(0), T(1), T(2), T(3), T(4), angular measurements which were carried out on lateral cephalograms at stages T(0) and T(4), and canine rotation measurements on study models, carried out at stages T(0) and T(4) were calculated and compared.
In this study the mean canine retraction by the TMA T-loop was more (5.46 mm) as compared with the mean retraction by the stainless steel T-loop (4.20 mm) (Table 1). The linear measurements using the TMA T-loop were observed to be greater in T(1), T(2) and T(3) and T(4) stages as compared to the stainless steel T-loop. This is because of low load-deflection rate, high M/F ratio and constant force delivery by the TMA wire (Graph 1).

It was seen that canine tipping by TMA T-loop was 4.35° in the first month, which went on increasing by approximately 1° each month, for the next 4 months. Similar observations were also seen in the stainless steel T-loop where canine tipping of 4.92° occurred in the first month, which went on increasing by approximately 1 to 1.5° each month, for the next 4 months (Table 2 and Graph 2). 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

<table>
<thead>
<tr>
<th>Stage</th>
<th>Group</th>
<th>Mean (degrees)</th>
<th>Standard deviation</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(0)</td>
<td>TMA</td>
<td>94.00</td>
<td>4.612</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>SS</td>
<td>94.00</td>
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<td>T(1)</td>
<td>TMA</td>
<td>98.25</td>
<td>2.454</td>
<td>0.557</td>
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<tr>
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<td>SS</td>
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<tr>
<td>T(2)</td>
<td>TMA</td>
<td>100.50</td>
<td>3.261</td>
<td>0.619</td>
<td>0.543</td>
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<tr>
<td></td>
<td>SS</td>
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<td></td>
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<tr>
<td>T(3)</td>
<td>TMA</td>
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<td>4.163</td>
<td>1.121</td>
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<td></td>
<td>SS</td>
<td>102.58</td>
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<tr>
<td>T(4)</td>
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<td></td>
<td>SS</td>
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<td>5.063</td>
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</table>

Graph 1: Means of intraoral linear measurements by stage comparison between TMA and SS
Table 3: Comparison of the means of lateral cephalogram canine angular measurements with FH plane, between TMA and SS groups at stages T(0) and T(4)

<table>
<thead>
<tr>
<th>Stages</th>
<th>Group</th>
<th>Mean (degrees)</th>
<th>Standard deviation</th>
<th>t-value</th>
<th>p-value</th>
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</thead>
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<tr>
<td>T(0)</td>
<td>TMA</td>
<td>89.50</td>
<td>8.130</td>
<td>0.621</td>
<td>0.541</td>
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<td></td>
<td>SS</td>
<td>87.83</td>
<td>4.509</td>
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<tr>
<td>T(4)</td>
<td>TMA</td>
<td>96.42</td>
<td>10.706</td>
<td>0.672</td>
<td>0.509</td>
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<tr>
<td></td>
<td>SS</td>
<td>99.00</td>
<td>7.920</td>
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Table 4: Comparison of the means of angular measurements of canine rotation, between TMA and SS groups at stages T(0) and T(4), taken on study model photographs

<table>
<thead>
<tr>
<th>Stages</th>
<th>Group</th>
<th>Relative mean (%)</th>
<th>Standard deviation</th>
<th>t-value</th>
<th>p-value</th>
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<tbody>
<tr>
<td>T(4)</td>
<td>TMA</td>
<td>50.8231</td>
<td>8.88639</td>
<td>2.117</td>
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<td></td>
<td>SS</td>
<td>39.4469</td>
<td>16.35537</td>
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due to inadequate time between activations for root uprighting. The intraoral angular readings were in harmony with the angular readings taken with FH plane on the lateral cephalogram (Table 3).

It was noted that canine rotation was more for the TMA T-loop group (50.82%) as compared to stainless steel T-loop group (39.44%) (Table 4). This rotation was more because TMA had more flexibility as compared to stainless steel indicating TMA had a weaker control as compared to stainless steel which was more rigid. Also rotation occurred in both the loops because of reduced antirotation bends of 35° as compared to 90° antirotation bends suggested by Marcotte and increased antirotation bends suggested by Nanda. Almost similar observations were also made by Ziegler and Ingervall in their study on canines which were rotated by 30° during 6 mm of canine retraction by using a PG spring.

These observations shed light on this very interesting and important aspect of segmented loop mechanics and its relation to the center of resistance, cross-section and material used for fabricating the T-loop. Both groups offered poor rotational control of canines. We can suggest more antirotation bends which may reduce this rotation. No other study came across which compared the efficiency between TMA and stainless steel T-loops in terms of canine retraction, canine tipping and canine rotation. After weighing the pros and cons, segmented T-loop mechanics could be commonly used in cases requiring faster and individualized canine retraction and less taxing on posterior anchorage. It also provides us with options in material and wire size in fabrication of the T-loops.

**CONCLUSION**

The following conclusions were drawn from the 4-month study:
1. Greater amount of maxillary canine retraction occurred using the 0.017 × 0.025 TMA T-loop (5.46 mm) as compared to the 0.016 × 0.022 stainless steel T-loop (4.20 mm).
2. The 0.017 × 0.025 TMA T-loop showed 7.83° tipping, whereas the 0.016 × 0.022 stainless steel T-loop showed 10° tipping, indicating that the TMA T-loop had better control.
3. The 0.016 × 0.022 stainless steel T-loop (39.44%) offered better rotational control over the 0.017 × 0.025 TMA T-loop (50.82%).

**REFERENCES**