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A Clinical Investigation into the Behaviour of Crimpable Archwire Hooks

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Abstract. *The objective of this study was to measure the force applied to attach crimpable hooks securely to rectangular stainless steel archwires, both inside and outside the mouth. A specially designed strain gauge was utilized to measure the force applied by each operator.* In vitro *testing of the attached hooks was carried out using an Instron Universal Testing Machine. Two operators crimped a total of 80 TP Orthodontic crimpable hooks to 0·019 × 0·025-inch stainless steel archwires.*

For one operator there was a significant difference between the intra- and extra-oral forces used to produce firmly attached crimpable hooks (P = 0·03). However, in vitro *testing demonstrated no statistically significant difference between the force levels required to displace the crimped hooks for either operator. The clinical significance of these findings is also discussed. Better reliability of crimpable hooks may be achieved by placing them out of the mouth.*

Index words: Crimpable Archwire Hooks, Strain Gauge Measurement.

Introduction

With the incorporation of individual tooth prescriptions in the pre-adjusted edgewise orthodontic bracket system, archwire fabrication has been considerably simplified (Andrews, 1972). Archwires that are devoid of any loops or customizing bends can be utilized, allowing free sliding of either groups of teeth (e.g. closure of residual extraction spaces) or individual teeth (e.g. canine retraction) along the archwire. The commonly used force delivery systems involve either elastomeric materials or nickel-titanium closed coil springs (Nattrass *et al.*, 1997), activated between the posterior anchorage units and the labial segment. Clinicians have at their disposal a number of different techniques for the application of these force delivery systems to the archwire. These include fabricated tie-back loops, soldered brass hooks, pre-posted archwires, and crimpable archwire hooks.

Tie-back loops can be difficult to bend in preformed archwires and, consequently, reduce the advantages of using the latter. Soldering requires chairside or laboratory equipment, is time-consuming and may lead to annealing of the archwire (Davies *et al.*, 1982; Alger, 1987). Pre-posted wires overcome these disadvantages, but require a large inventory of stock, with obvious cost implications. In contrast, crimpable archwire hooks allow quick and simple placement of the hooks in any desired position along the archwire in or out of the mouth. These hooks also offer a number of advantages in patients undergoing orthodontic preparation for orthognathic surgery, permitting intermaxillary fixation to be applied and facilitating the post-surgical use of elastics. As a result, crimpable archwire hooks have the potential for cost savings in both time and materials and are associated with minimum discomfort. However, excessive force during crimping can cause both distortion of the wire and the introduction of unwanted force into the wire (Evans and Jones, 1991). TP Orthodontics have recently promoted their new crimpable hook with the Never-Slip™ Grip. The hook is made with a tungsten carbide inner coating designed to resist movement.

Griffin and Ferracane (1998) examined the effects of sandblasting and/or the use of dental adhesives on the stability of crimpable hooks when positioned and crimped onto surgical archwires. The combination of sandblasting and dental adhesive increased the force required to dislodge the hook by a factor of 10. More recently, *in vitro* testing of two different manufacturers' hooks demonstrated significant differences in behaviour (Johal *et al.*, 1999). Very little research has been undertaken to evaluate the resistance to sliding of newly introduced crimpable archwire hooks within the clinical environment, despite their extensive use in everyday clinical practice.

The aim of the present study was to compare the force required to move crimpable archwire hooks placed either inside or outside the mouth.

Materials and methods

A total of 80 crimpable hooks from TP Orthodontics (LaPorte, Indiana, USA) were tested (Figure 1). The method used to control and measure the force applied during the crimping process has been previously described (Johal *et al.*, 1999). A further modification of the apparatus was required to facilitate clinical use. A pair of strain gauges were bonded in a half bridge configuration to the TP crimping pliers.

Two operators (SL and JH) each crimped 40 hooks to a preformed 0·019 × 0·025-inch stainless steel wire. Twenty hooks were placed with the archwire engaging the pre-

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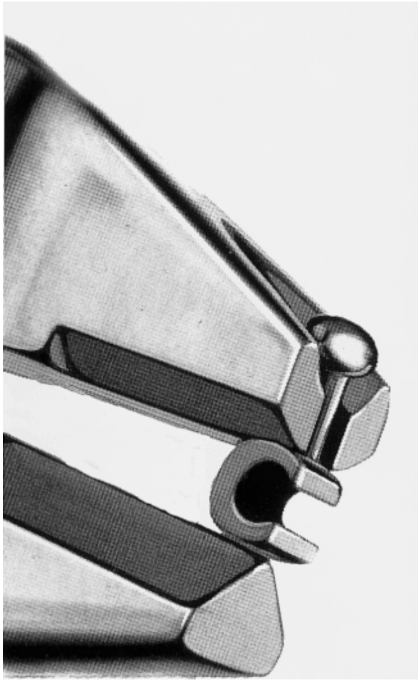

FIG. 1 TP crimpable hook being held in the specifically designed TP crimpable hook placement pliers.

adjusted edgewise system in the mouth at a point midway between the lateral incisor and canine brackets, whilst the remaining 20 hooks were placed outside the mouth in a contralateral position.

In order to determine the effect, if any, of crimping hooks inside or outside the mouth the archwire wire was then mounted in an Instron Model 1193 Universal Testing machine (Instron Corporation, Canton, Massachusetts, USA) with a 0·7-mm loop attached from the hook to the load cell. The force required to move the hook was then determined at a rate of 0·5 mm/min.

Results and Data Analysis

Data were analysed using StatXact 3 for Windows (StatXact, Cambridge, USA). Significance was predetermined at $\alpha = 0{\cdot}05$. The Shapiro–Francia test was used to test the data for normality. The data were not normally distributed and, consequently, exact non-parametric inferential data analysis was used.

Summary statistics comparing the force levels required to produce firmly attached crimpable hooks both inside and outside the mouth, for each operator, are provided in Table 1. The Wilcoxon signed rank test demonstrated a statistically significant difference between these values for operator JH ($P = 0{\cdot}0269$), whilst no such difference was detected for SL ($P = 0{\cdot}4011$). Furthermore, the mean crimping forces for operator JH both intra- and extra-orally was higher than those of the second operator, with a difference of 2·0 and 3·2 KgF, respectively.

Summary statistics comparing the force levels required to displace the crimped hooks placed intra- and extra-orally, using the Instron Universal Testing machine, for both operators are given in Table 2. The Wilcoxon signed rank test demonstrated no statistically significant difference between these values for either operator JH ($P = 0{\cdot}3633$) or SL ($P = 0{\cdot}9055$). The mean force required to produce movement of the crimped hooks placed by JH, was higher for both intra- and extra-orally placed hooks compared to those placed by SL. However, the standard deviation (8·77 and 12·37 N, respectively) was also significantly higher.

Discussion

No previous study has investigated the magnitude of force used by clinicians to apply crimpable archwire hooks at the chairside. Evans and Jones (1991), in their laboratory study designed to evaluate AO hooks, reported a mean force of between 2·97 and 3·33 N for the two male operators, and 0·88 N for the female operator. Whilst the differences were attributed to the lesser physical strength associated with the female operator, nevertheless, the median values were in

TABLE 1 *Summary statistics for each operator of the force levels required to produce firmly attached crimpable hooks intra- and extra-orally. In all experiments the sample size is 20*

Operator	Extra-oral				Intra-oral			
	Mean	SD	Min	Max	Mean	SD	Min	Max
JH	22·05	2·24	16	25	20·45	1·57	18	24
SL	18·85	1·27	17	22	18·45	1·70	15	22

Mean (mean crimping force in kg); SD (standard deviation); Min (minimum); Max (maximum).

TABLE 2 *Summary statistics for each operator of the force levels required to displace the crimped hooks using the Instron Universal Testing machine. In all experiments the sample size is 20*

Operator	Extra-oral				Intra-oral			
	Mean	SD	Min	Max	Mean	SD	Min	Max
JH	22·78	12·37	4	48·50	20·01	8·77	1	41·25
SL	15·65	9·77	5·25	44·25	14·78	7·47	2·5	32·50

Mean (mean force in N); SD (standard deviation); Min (minimum); Max (maximum).

the order of 3 N. Griffin and Ferracane (1998), examined the effect of sandblasting and/or dental adhesives on the stability of crimpable hooks. A mean force of 2 N was required to dislodge hooks attached to a 4-cm length of 0·019 × 0·025-inch stainless steel wire by crimping alone, but the force required to dislodge the hook was increased by a factor of 10 where sandblasting and adhesives were used. However, the authors failed to report the type of archwire or crimpable hooks employed in their study, and their only criterion regarding the force level applied in attaching the hooks was that no bending of the archwire should occur. Their concern for inadvertent distortion of the archwire could explain why the force required to dislodge the hooks subjected to crimping alone was found to be so low. In an attempt to address the problem of determining the magnitude of force used to apply crimpable archwire hooks, Johal *et al*. (1999) designed a custom-made unit, for laboratory use, which permitted the investigation of the force used by clinicians to attach hooks to rectangular stainless steel archwires. The authors found that almost twice the force was needed to dislodge the TP hooks compared with that required to make the AO hooks slide, 11·7 and 6·22 N, respectively. However, the standard deviation (6·78 N) for the TP hooks was significantly higher than for the AO hooks (0·76 N). There is no obvious explanation for this finding as the crimpable hooks were attached using a pair of new pliers specific to each hook manufacturer.

In the present study, further modification of the equipment permitted the investigation of the force used by clinicians, of different gender, to produce firmly attached hooks both intra- and extra-orally. The mean values for the male operator was significantly higher than for the female (Table 1). This not only confirms our previous findings (Johal *et al*., 1999), but also the subjective opinion of other workers (Evans and Jones, 1991).

Furthermore, the findings also demonstrate that placement of crimpable hooks outside the mouth enables a higher force value to be used, which offers greater clinical reliability. Nattrass *et al*. (1997), in their comparison of the different force delivery systems used, reported that clinicians applied extremely wide ranges of force (0·44–3·54 N) to the dentition during space closure. Furthermore, Frost (1990) reported that lower levels of force are required to achieve bone remodelling and tooth movement. Thus, it would appear that the magnitude of force required to produce sliding of TP hooks should not be reached clinically, even allowing for the high standard deviation. However, the authors suggest that, in view of the above findings, clinicians could ensure better reliability of crimpable hooks by attaching them to the archwire outside the mouth.

Conclusions

1. Clinicians produce more firmly attached crimpable hooks when they are placed outside the mouth.
2. TP crimpable hooks show a wide variation in the force required to dislodge them.

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