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Three Palatal Arches Used to Correct Posterior Dental Crossbites

Fernando Lima Martinelli;[a] Priscilla Sobral Couto;[b] Antonio Carlos Oliveira Ruellas[c]

ABSTRACT

Objective: To assess the force, resilience, and elasticity modulus produced by the Coffin appliance, "W" arch, and quad-helix made with 0.032-inch and 0.036-inch stainless steel wire.

Materials and Methods: Two groups of 15 arches were made as Coffin appliances, two groups of 15 arches were made as "W" arches, and two groups of 15 arches were made as quad-helices. One group of each appliance was formed in 0.032-inch and one group in 0.036-inch stainless steel wire. All arches (6 groups of 15 each) were submitted to compression trials in the mechanical testing machine EMIC DL-10000, simulating 5-, 8-, 10-, and 12-mm activation. The force and resilience means received a one-way ANOVA statistical analysis.

Results: The results showed that the mechanical properties depended on the shape of the appliance, the diameter of the wire used, and the amount of activation.

Conclusions: The three appliances assessed produce appropriate forces for orthodontic treatment as long as they are correctly planned during clinical application.

KEY WORDS: Crossbite, Appliances, Force.

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INTRODUCTION Return to TOC

The posterior crossbite is defined as the abnormal buccolingual relation between the upper and lower arches, classified according to the anatomic reference, location, or etiology. The crossbite can be classified as skeletal, dental, or functional.[1–3]

Appropriate correction of the posterior skeletal crossbite is reached by maxillary expansion, introduced by Wescott[4] and Angell[5] at the end of the 19th century. Haas[6] described the technique of midpalatal splitting, which became a common procedure to correct the skeletal etiology associated with constricted upper arches.

The treatment of posterior dental crossbite has been regarded as the correction of the buccolingual tipping of a single or group of teeth and reestablishing the balance between the upper and lower arches.[1–6] There has been an evolution in the shape of the appliances to correct such malocclusion through the years. The appliances commonly used to correct the dental crossbite include the Coffin appliance, the "W" Arch and the quad-helix arch.[7–9]

The Coffin appliance, described by Walter Coffin in 1881, was originally used in removable plates to expand constricted arches, and its clinical application is still often recommended.[9,10] The "W" arch is an evolution of the Coffin appliance, differing in shape and size as well as using fixed anchorage. In order to increase flexibility and make the released force magnitude light and continuous, helices were initially introduced in the posterior segment of the palatal arch (bihelix). Later, two more helices were introduced in the anterior part of the arch creating the quad-helix.[7,10,11]

Erdinç et al[12] compared the application of quad-helix appliances and expansion plates in dental crossbite treatment. They found a fairly short period of time necessary for correction when using the quad-helix appliance, but the appliance caused considerable buccal tipping of the maxillary first permanent molars.

Graber[13] stated that 400 g was the least force required to achieve an orthopedic effect in the maxillary arch. Haas,[14] however, inferred that it is necessary to use more than 1000 g. Clinical studies corroborated that the "W" arch and quad-helix appliances provide suture splitting, accelerating the normal expansion of the midpalatal suture, during the deciduous and mixed dentition.

Conversely, posterior dental crossbite correction requires orthodontic forces, and Jarabak and Fizzell[15] recommended ideal force levels for each group of teeth. They suggested 250 g for upper molar movement.

Although the methods to correct the posterior dental crossbite have evolved, there is still doubt regarding the choice of appliance and activation to achieve ideal force for orthodontic movement. The aim of this study was to assess the force, resilience and elasticity modulus means during 5, 8, 10, and 12 mm of activation in three different types of expansion appliances used to correct posterior dental crossbite and to determine ideal levels of activation for each appliance.

MATERIALS AND METHODS Return to TOC

A total of 90 appliances were tested, using two sizes of wire in three configurations.

Fifteen Coffin appliances were made out of 0.032-inch stainless steel wire and 15 were made out of 0.036-inch stainless steel wire. The Coffin appliance had two 25-mm legs and a posterior loop that measured 10 mm (Figure 1A).

Fifteen "W" arch appliances were made out of out of 0.032-inch stainless steel wire and 15 were made out of 0.036-inch stainless steel wire. The "W" arch (Figure 1B) had two 40-mm outer legs and two 35-mm inner legs, and the anterior section was 10 mm.

Fifteen quad-helix appliances were made out of 0.032-inch stainless steel wire and 15 were made out of 0.036-inch stainless steel wire. The quad-helix had the same dimensions as the "W" arch, but had four 1.5-mm diameter helices were incorporated in the arches (Figure 1c).

The samples were manufactured by the same professional, using a template with standardized intercanine and intermolar distances. A 5-mm segment of a 0.040-inch telescopic tube was attached to the posterior part of each external leg of the "W" arches and quad-helices in order to locate the force application in the first upper permanent molars. A 10-mm segment of stainless steel of 0.032-inch diameter was welded with heavy silver solder in the core of the telescopic tube so that the appliance could be fixed to the universal trial machine.

Each sample was first activated at 10 mm and then submitted in sequence to compression trials in the EMIC DL 10000 machine, using the Mtest program 1.01 version, at a speed of 5 mm/min. The Mtest program provided the force and resilience means produced by 5-, 8-, 10-, and 12-mm activation, as well as the mechanical behavior graph of each appliance in this activation index. The elasticity modulus was calculated based on the arch dimensions, the wire diameter, and the force means obtained for each appliance shape. The results obtained for each group were statistically compared by one-way ANOVA analysis.

RESULTS Return to TOC

Force, resilience, and elasticity modulus increased proportionally to the activation increases (Tables 1 and 2). In addition, the groups using the 0.036-inch wire presented statistically ($P < .01$) higher levels of force and resiliency when compared to the arches using the 0.032-inch wire (Figure 2). On average, the Coffin arch produced the highest levels of force, followed by the "W" arch, and the quad-helix showed the lowest values (Table 1).

Coffin appliances also showed significantly ($P < .01$) higher resilience comparing to the others (Table 2). The "W" arches showed statistically ($P < .01$) higher force and resilience than the quad-helix using the same diameter wire; however, 0.032-inch "W" arches and 0.036-inch quad-helices did not present statistically significant differences (Figure 3). Averages of elasticity modulus were higher in the Coffin group, followed by the "W" arch and then the quad-helix (Table 2). The larger the diameter of wire, the larger was the elasticity modulus, even in appliances with the same shape.

DISCUSSION Return to TOC

Force analysis in a 5-mm activation of each arch and comparison among the groups presented significant differences ($P < .01$) in most of the results, except for the comparison between the means of the 0.036-inch quad-helix and the 0.032-inch "W" arch (Table 1).

Statistical analysis for 8-, 10-, and 12-mm activations provided similar results to those found in the 5-mm activation analysis. The mean force values increased proportionally to the activation, corroborating that the appliances worked in the elastic phase, in which deformation is proportional to force.

Resilience is the property associated with the capacity of absorbing and releasing energy; thus, the higher the resilience, the more continuous the force. The elasticity modulus is directly proportional to the stiffness, and, in orthodontics, the higher the elasticity modulus, the lower the amount of tooth movement.[16]

Several studies have been reported concerning different shapes of palatal arches to correct posterior dental crossbites.[3,9,11,17] In the present study, different appliances provided distinct mechanical properties, indicating the need for acquiring knowledge of the performance of the appliance to be chosen. In addition, it is important to identify the etiology of such malocclusion and to determine the ideal force for each treatment.[1] The movement of a single molar might use 250 g,[15] but orthopedic effects are noted in deciduous and mixed dentition with forces higher than 400 g.[13] Severely constricted upper arches with a skeletal etiology must be corrected using rapid palatal expansion, following the protocol advocated by Haas.[6]

According to Adams,[9] the amount of activation in the Coffin appliance depends on the length and diameter of the arch and the number of teeth to be moved. An activation range from 2 to 4 mm using a 0.050-inch wire has been proposed as being sufficient at the beginning. If new adjustments are necessary, they can be made afterwards. This activation is corroborated by the present study, but the need to use a thinner wire diameter is also suggested when the etiology is a dental abnormality.

Proffit[8] suggested that the success of removable appliances depends on the patient's cooperation and on controlling the force of the appliance. He analyzed the use of the "W" arch and recommended 3 or 4 mm of activation as adequate levels of force when using a 0.036-inch wire.

Urbaniak et al[17] observed that the force produced by the quad-helix activation is influenced by the size and wire diameter of the appliance. This study reported that the amount of wire used in the palatal arch and the force are inversely proportional, whereas the wire diameter is directly proportional to the force. Other studies concerning the quad-helix appliance[7,10,11] suggested the use of a force of approximately 400 g for an activation of 8 mm. According to the present study, the most appropriate force was the one obtained with the "W" arch using a 0.036-inch wire and a 12-mm activation. This difference might be caused by differences in the size of the appliances and the wire diameter used.[17]

Finally, the crossbite of a single molar or a group of a few teeth is appropriately treated with a 0.036-inch quad-helix or a 0.032-inch "W" arch, using 10 to 12 mm of activation. A 0.032-inch quad-helix with 12-mm activation provides a very light force and can be used to correct the crossbite of a single tooth. When a slight orthopedic effect is expected during the deciduous and mixed dentition, a 0.036-inch "W" arch with 12 mm of activation appears to be the best choice. The Coffin appliance with a 5-mm activation presents a heavy force, and the findings suggest that orthopedic effects can be reached in cooperative patients or in fixed appliances using this arch shape in either 0.032-inch or 0.036-inch wires. However, clinical studies are necessary to evaluate the validity of the in vitro findings reported in the present study.

CONCLUSIONS Return to TOC

- The Coffin appliance produces high force values and should be made with 0.032-inch wire and used with no more than 5 mm of activation.
- The "W" arch works at an ideal force when made with 0.032-inch wire and 12 mm of activation to obtain dental correction, or with 0.036-inch wire and 8– 12 mm of activation when expecting orthopedic effects in deciduous and mixed dentition.
- The quad-helix provides adequate forces for dental crossbites when manufactured with a 0.036-inch wire and activated at 12 mm.

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TABLES Return to TOC

Table 1. Force (g) Means Produced by the Different Groups of Palatal Arches[a]

Shape	Wire Diameter	Activation Rate 5 mm	8 mm	10 mm	12 mm
Coffin	0.032	357.8 ± 27[a]	530.3 ± 31 a	630 ± 35 a	722 ± 34 a
	0.036	518 ± 34 b	779.6 ± 54 b	935 ± 68 b	1080 ± 82 b
"W" arch	0.032	114.6 ± 9 c	178 ± 14 c	218.9 ± 16 c	259.3 ± 18 c
	0.036	174.5 ± 11 d	268.6 ± 15 d	327.3 ± 17 d	383.4 ± 19 d
Quadhelix	0.032	72.6 ± 3 e	113.9 ± 5 e	140.9 ± 7 e	172.1 ± 13 e
	0.036	105.5 ± 3 c	165.8 ± 4 c	205.1 ± 4 c	244.4 ± 5 c

[a] n = 15 for each shape and wire diameter combination.
[b] Statistical difference ($P < .01$) is indicated by different full-size lowercase letters; same letters indicate no significant difference.

Table 2. Resilience Mean and Elasticity Modulus Produced by the Three Palatal Arches

Shape	Wire Diameter	Resilience (g·cm)	Elasticity Modulus (g/cm²)
Coffin	0.032	465.3 ± 28[a]	90.2
	0.036	677.4 ± 37 b	107.1
"W" arch	0.032	155 ± 9 c	73.4
	0.036	242 ± 14 d	86.1
Quad-helix	0.032	101 ± 4 e	58.5
	0.036	149.6 ± 4 c	66.0

[a] n = 15 for each shape and wire diameter combination.
[b] Statistical difference ($P < .01$) is indicated by different full-size lowercase letters; same letters indicate no significant difference.

FIGURES Return to TOC

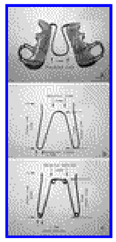

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Figure 1. Expansion palatal arches assessed: (A) Coffin appliance, (B) “W” arch, and (C) quad-helix

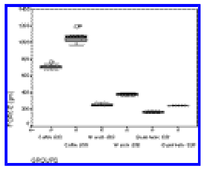

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Figure 2. Box plot depicting force (g) means of each appliance and statistical differences among the groups observed at the final (12-mm) activation

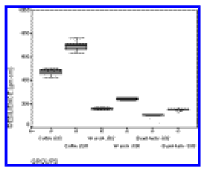

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Figure 3. Resilience (g·cm) means of each group and statistical comparison among all the appliances observed in the box plot

[a]Graduate Student (PhD), Department of Orthodontics, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil

[b]Resident, Department of Orthodontics, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil

[c]Assistant Professor, Department of Orthodontics, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil

Corresponding author: Dr. Fernando Lima Martinelli, Department of Orthodontics, Universidade Federal do Rio de Janeiro, Rua Mariante, 239/306, Porto Alegre, RS, Brazil 90430-181 (E-mail: flima.ez@terra.com.br)