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Research

Comparación del tamaño transversal de los arcos 0.012, 0.014 y 0.016 de NiTi de tres marcas

Comparison of the cross-sectional size of the 0.012, 0.014 and 0.016 NiTi archwires of three brands

Comparação do tamanho transversal dos arcos 0.012, 0.014 e 0.016 de NiTi de três marcas

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Resumen

Objetivo: Determinar si existen diferencias en el tamaño de los arcos de NiTi en los calibres 0.012, 0.014 y 0.016 de tres marcas comerciales. Material y métodos: Se utilizaron 180 arcos de NiTi de las marcas American Orthodontics, TD Orthodontics y OrthoPremium. La estadística descriptiva, la ANOVA y el Post Hoc se realizaron en el programa SPSS 18. Resultados: los arcos de American Orthodontics presentaron diferencias estadísticas significativas en la parte anterior y posterior. En los arcos superiores de TD Orthodontics se encontró contracción en el calibre 0.016. En los arcos superiores OrthoPremium presento una contracción en la parte anterior y en el arco inferior de los 10 a los 40mm. Al comparar las tres marcas se encontraron diferencias estadísticas significativas ($p<0.05$) entre ellas con las pruebas de ANOVA. Conclusiones: existen diferencias en los tamaños de los arcos superiores e inferiores de cada marca y entre ellas.

Palabras Clave: Arcos, Níquel Titanio, ortodoncia.

Abstract

Objective: To determine if there are differences between the 0.012, 0.014 and 0.016 NiTi archwires of three brands.

Material and methods: 180 NiTi archwires of the following brands were used: American Orthodontics, TD Orthodontics and OrthoPremium. Descriptive statistics, ANOVA and Post Hoc were performed using SPSS 18 software.

Results: The American Orthodontics archwires presented significant statistical differences in the anterior and posterior parts. In the TD Orthodontics upper archwires, contraction was found in the 0.016 caliber. In the upper archwires, OrthoPremium presented a contraction in the anterior part and in the lower archwire of 10 mm to 40 mm. When comparing the three brands, significant statistical differences ($p <0.05$) were found between them with the ANOVA tests.

Conclusions: There are differences in the sizes of the upper and lower archwires of each brand and between them.
Keywords: archwire; nickel-titanium alloy; orthodontics

Resumo
Objetivo: determinar se existem diferenças no tamanho dos arcos de NiTi em calibres 0, 12, 0, 14 e 0, 16 de três marcas comerciais. Material e métodos: foram utilizados 180 arcos NiTi das marcas American Orthodontics, TD Orthodontics e OrthoPremium. Estatística descritiva, ANOVA e Post Hoc foram realizadas no programa SPSS 18. Resultados: os arcos da American Orthodontics apresentaram diferenças estatísticas significativas na parte anterior e posterior. Nos arcos superiores da TD Ortodontia foi encontrada contração no calibre 0, 16. Nos arcos superiores, o OrthoPremium apresentou contração na parte anterior e no arco inferior de 10 a 40mm. Ao comparar as três marcas, foram encontradas diferenças estatísticas significativas ($p < 0,05$) entre elas com os testes ANOVA. Conclusões: existem diferenças nos tamanhos dos arcos superior e inferior de cada marca e entre eles.
Palavras-chave: arcos, níquel titânio, Ortodontia.

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Introduction

The forces that lead to orthodontic tooth movement come from the dental archwires, which store energy that is released upon contact with the brackets. This creates biomechanical forces that produce tooth movement[1-2].

The archwires must transmit light and continuous forces to avoid damaging the periodontium and inducing root resorption. They must have the following properties to work properly: stiffness, biocompatibility, fracture toughness, adequate elasticity, moldability, corrosion resistance, good aesthetics, among others[3-4].

Nickel titanium (NiTi) archwires were introduced in the 1970s. This alloy has shape memory and superelasticity resulting from the martensite-to-austenite transformation. This allows it to recover its lost shape after undergoing macroscopic deformation, no corrosion is observed and there is also compatibility[1,5-6].

Nowadays, the selection of the NiTi archwire and its shape depend on the patient's arch type, which has been classified as narrow or tapered, ovoid, or square[7].
Over time, professionals have tried to agree on a single dental arch shape, which has not been possible as there are several factors that influence it such as supporting bone, tooth eruption, orofacial muscles, intraoral functional forces, as well as genetics, sex and race[7-9].
However, three shapes are suggested for classification purposes: narrow or tapered, square and ovoid. Such forms have been created based on four major arch aspects: anterior curvature, intercanine width, intermolar width and posterior curvature[7,10].
Classifying the arch shape is crucial for the orthodontist, especially when using shape-memory archwires, as they store and carry information to adjacent teeth and tissues. If the arch is not correctly classified, this may lead to problems such as uncoordinated arches, which may affect aesthetic and functional results[8,10].

Material and methods

This study was conducted within the Postgraduate Degree in Orthodontics of the Autonomous University of Nayarit, in the city of Tepic, Nayarit. It is a descriptive, observational and cross-sectional study. It was prepared by a single operator (calibration test). The sample included 180 NiTi archwires (90 upper and 90 lower archwires); 10 upper and 10 lower archwires of 0.012, 0.14 and 0.016 calibers of the following brands were used: American Orthodontics (AO), TD Orthodontics (TD) and OrthoPremium (OP). They are manufactured by Hangzou Yamei. The following shapes were used: American Orthodontics, Natural Arch Form I; Orthodontics, ovoid; and OrthoPremium, ovoid.
All measurements were made by a single operator. The following procedure was followed to measure the archwire: the wires were placed on millimeter paper with the parable vertex on the intersection of a horizontal line and a vertical line. The operator checked that the archwire was symmetrical on both sides of the vertical line passing through the midline. Once the archwire was centered, on the vertical line and from the vertex, the archwire was divided into 6 parts every 10 mm (10 mm, 20 mm, 30 mm, 40 mm, 50 mm and 60 mm deep), measuring the archwire transversely in those areas (Fig. 1).
Materials used: NiTi archwires, Pochteca millimeter paper, pencil, log sheets, computer. The data were recorded in a Microsoft Excel spreadsheet. SPSS 18 software was used to apply descriptive statistics and conduct an ANOVA test.

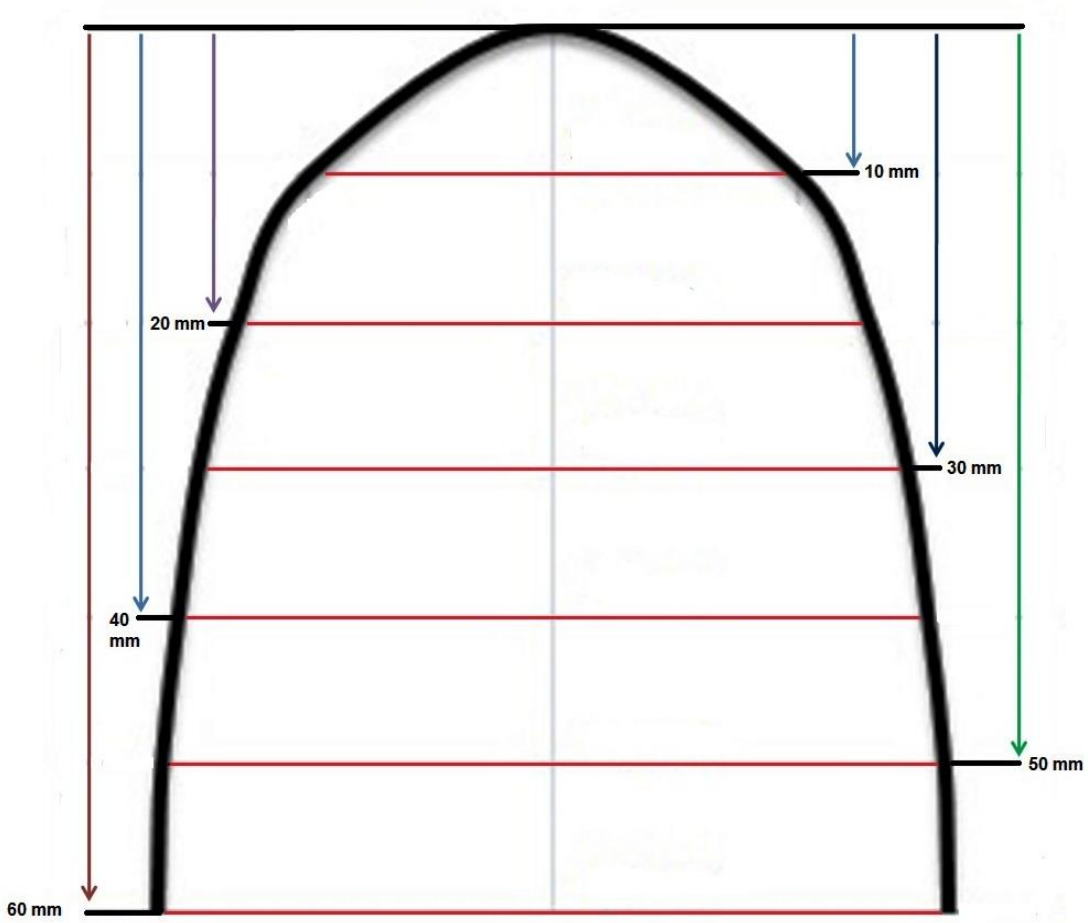

Fig. 1: Archwire depth where the inner part was measured transversely

Results

Tables 1 and 2 show the average and standard deviation of the upper and lower archwires. The American Orthodontics NiTi archwires showed statistically significant differences at 10 mm, 50 mm and 60 mm in the upper archwires. Tukey's post hoc test showed significant differences at 10 mm, 50 mm and 60 mm in the upper arches between the 0.012 archwires and the others, but when comparing the 0.014 with the 0.016 archwire, no differences were found (Table 3).

Statistically significant differences at 20 mm, 50 mm and 60 mm were found in the American Orthodontics lower archwires. Tukey's post hoc test showed significant differences at 20 mm, 50 mm and 60 mm between the 0.012 archwires and the others, but when comparing the 0.014 to the 0.016 archwire, there were statistically significant differences only at 60 mm (Table 3).

The TD Orthodontics upper archwires showed statistically significant differences in the upper arches at 10 mm, 30 mm, 40 mm, 50 mm and 60 mm (Table 4). Tukey's post hoc results showed no statistically

significant differences at 10 mm and 30 mm between 0.012 and 0.014 archwires; however, there were statistically significant differences between the 0.012 and 0.016 archwires, as well as in the 0.014 and 0.016 ones. At 40 mm and 60 mm, there were only differences between the 0.012 and 0.016 archwires. Statistically significant differences were found at 50 mm between the 0.012 archwires and the 0.014 and 0.016 ones; no statistically significant differences were found between the 0.014 and 0.016 archwires (Table 4).

The TD Orthodontics lower archwires showed statistically significant differences at 10 mm and 20 mm. Tukey's post hoc test at 10 mm and 20 mm showed that 0.012 archwires are different from the 0.014 and 0.016 ones (Table 4).

Statistically significant differences were found in the OrthoPremium upper archwires at 10 mm, 50 mm and 60 mm. Tukey's post hoc test at 10 mm showed differences between the 0.012 archwires and the 0.014 ones, and also between the 0.014 and 0.016 archwires. Statistically significant differences were found in the lower archwires in all measurements. Tukey's post hoc test showed statistically significant differences between 0.012 archwires and 0.014 and 0.016 archwires. However, no statistically significant differences were found between the 0.014 and 0.016 archwires (Table 5).

When comparing the average of the three archwires, statistically significant differences ($p<0.01$) were found in all the mean measurements of both upper and lower archwires. The result of Tukey's post hoc test when comparing TD Orthodontics and American Orthodontics showed no statistically significant differences at 20 mm and 30 mm in the upper archwire and at 10 mm and 20 mm in the lower archwire. There were no statistically significant differences between TD Orthodontics and Orthopremium archwires; only in archwires greater than 10 mm. When comparing American Orthodontics archwires to OrthoPremium ones, no statistically significant differences were found in archwires larger than 40 mm (Table 6).

Tables

Table 1. Average and standard deviation of upper arches

	American Orthodontics			TD Orthodontics			OrthoPremium		
mm	0.012	0.014	0.016	0.012	0.014	0.016	0.012	0.014	0.016
10	39.8 ±1.5	42.1 ±0.7	42±0 .001	39.7 ±0.6	39.5 ±0.5	38.2 ±0.9	39.3± 0.67	39.9 ±0.3	38.8 ±0.4

	4	3		7	2	1		1	2
20	51.2 ±0.42	51.5 ±0.52	51.7 ±0.48	51.5 ±0.7	51.5 ±0.7	50.9 ±1.2	50.1± 0.31	49.9 ±0.32	49.8 ±0.41
30	57.4 ±0.51	57.6 ±0.51	57.7 ±0.47	57.8 ±0.42	57.5 ±0.52	56.6 ±0.51	56.1± 0.316	55.9 ±0.31	56.3 ±0.48
40	60.1 ±0.31	60.5 ±0.52	60.6 ±0.51	61.3 ±0.82	60.6 ±0.51	60.5 ±0.52	59.8± 0.42	59.5 ±0.52	59.7 ±0.67
50	62.1 ±0.73	60.7 ±0.47	61.1 ±0.31	63.8 ±0.78	63±0 .01	62.6 ±0.51	61.3± 0.48	60.5 ±0.51	61.1 ±0.56
60	63±1 .15	60.6 ±0.48	61.4 ±0.51	64.5 ±0.52	64±0 .47	63.6 ±0.51	61.3± 0.52	60.5 ±0.52	61.3 ±0.48

Table 2. Average and standard deviation of lower arches

	American Orthodontics			TD Orthodontics			OrthoPremium		
mm	0.012	0.014	0.016	0.012	0.014	0.016	0.012	0.014	0.016
10	38.2 ±1.03	38.8 ±0.63	38.8 ±0.42	38.8 ±0.42	38±0. 66	37.9 ±0.56	38.8 ±0.63	36.7 ±0.48	36.5 ±0.52
20	48.6 ±0.51	47.9 ±0.56	47.5 ±0.5	48.4 ±0.53	49.1± 0.56	49±0 .66	47.9 ±0.56	46.8 ±0.42	47.1 ±0.56
30	53.3 ±0.48	53±0 .47	53.4 ±0.26	54.4 ±0.52	54.2± 0.42	54.2 ±0.63	53±0 .47	52.8 ±0.42	52.4 ±0.51
40	56.4 ±1.26	54.9 ±0.47	56.6 ±0.01	58.4 ±0.51	58.1± 0.316	58.2 ±0.42	56±0 .01	54.9 ±0.56	55.2 ±0.42
50	57.7 ±0.91	55.8 ±0.42	55.8 ±0.42	60.5 ±0.52	60.1± 0.31	60.3 ±0.67	56±0 .01	56.8 ±0.42	57.2 ±0.63
60	57.8 ±0.94	64.6 ±0.51	55.8 ±0.42	61±0 .47	61±0. 001	61.1 ±0.56	55.8 ±0.42	57.1 ±0.31	57.3 ±0.48

Table 3. ANOVA and Tukey's Post hoc tests on American Orthodontics archwires

		ANOVA		Post hoc		
	Archwire	F	p	0.012 vs 0.14	0.012 vs 0.016	0.014 vs 0.016
10	Upper	17.21	0.000**	0.000**	0.000**	0.97[a]
	Lower	2.105	0,141[a]	0,086[a]	0,088[a]	0,991[a]
20	Upper	2.75	0,081[a]	0,355[a]	0,068[a]	0,624[a]
	Lower	8.587	0.001**	0.015*	0.000**	0.15[a]
30	Upper	0.91	0.41[a]	0,654[a]	0,393[a]	0,898[a]
	Lower	1.79	0,186[a]	0,184[a]	0.65[a]	0.80[a]
40	Upper	3.25	0,054[a]	0.15[a]	0,058[a]	0.88[a]
	Lower	1.32	0,283[a]	0,128[a]	0,684[a]	0,257[a]
50	Upper	17.7	0.000**	0.000**	0.001**	0,241[a]
	Lower	6.84	0.004**	0.003**	0.002**	0.92[a]
60	Upper	22.74	0.000**	0.000**	0.000**	0,131[a]
	Lower	67.25	0.000**	0.000**	0.000**	0.004**
[a]No statistically significant difference, * p < 0.05, ** p < 0.01						

Table 4. ANOVA and Tukey's Post hoc tests on TD Orthodontics archwires

		ANOVA		Post hoc		
	Archwire	F	p	0.012 vs 0.14	0.012 vs 0.016	0.014 vs 0.016
10	Upper	12.61	0.000**	0,812[a]	0.000**	0.001**
	Lower	7.72	0.002**	0.004**	0.001**	0,693[a]
20	Upper	1.35	0,275[a]	0.99[a]	0,342[a]	0.34[a]
	Lower	4.16	0.027*	0.013*	0.030*	0,706[a]
30	Upper	16.2	0.000**	0,372[a]	0.000**	0.001**
	Lower	0.474	0.62[a]	0,407[a]	0.41[a]	0.98[a]
40	Upper	4.664	0.018*	0.053[a]	0.024*	0.93[a]
	Lower	1.286	0.293[a]	0.12[a]	0.303[a]	0.604[a]
50	Upper	12.6	0.000**	0.008**	0.000**	0.245[a]
	Lower	1.44	0.255[a]	0.101[a]	0.404[a]	0.406[a]
60	Upper	7.95	0.002**	0.087[a]	0.001**	0.199[a]
	Lower	0.184	0.833[a]	0.96[a]	0.604[a]	0.600[a]
[a]No statistically significant difference, * p < 0.05, ** p < 0.01						

Table 5. ANOVA and Tukey's Post hoc tests on OrthoPremium archwires

		ANOVA		Post hoc		
	Archwire	F	p	0.012 vs 0.14	0.012 vs 0.016	0.014 vs 0.016

10	Upper	12.409	0.000**	0.03*	0.07[a]	0.000**
	Lower	53.45	0.000**	0.000**	0.000**	0.424[a]
20	Upper	1.853	0.176[a]	0.429[a]	0.161[a]	0.805[a]
	Lower	11.79	0.000**	0.000**	0.002**	0.211[a]
30	Upper	2.76	0.081[a]	0.477[a]	0.477[a]	0.065[a]
	Lower	4.2	0.026*	0.351[a]	0.008**	0.069[a]
40	Upper	0.768	0.474[a]	0.454[a]	0.914[a]	0.699[a]
	Lower	19.4	0.000**	0.000**	0.000**	0.112[a]
50	Upper	6.24	0.006**	0.006**	0.677[a]	0.043*
	Lower	19.38	0.000**	0.000**	0.000**	0.051[a]
60	Upper	8.59	0.001**	0.004**	0.99[a]	0.004**
	Lower	38.93	0.000**	0.000**	0.000**	0.288[a]
[a]No statistically significant difference, * p < 0.05, ** p < 0.01						

Table 6. ANOVA and Tukey's Post hoc tests on archwires belonging to the three brands

		ANOVA		Post hoc		
	Archwire	F	p	TD vs AO	TD vs OP	AO vs OP
10	Upper	29.78	0.000**	0.000**	0.189[a]	0.000**
	Lower	20.96	0.000**	0.66[a]	0.000**	0.002**
20	Upper	14.084	0.000**	0.98[a]	0.000**	0.008**
	Lower	20.021	0.000**	0.164[a]	0.018*	0.002**
30	Upper	26.74	0.000**	0.59[a]	0.000**	0.000**
	Lower	19.99	0.000**	0.000**	0.000**	0.018*
40	Upper	10.32	0.000**	0.000**	0.000**	0.290
	Lower	12.484	0.000**	0.001**	0.000**	0.010**
50	Upper	44.56	0.000**	0.000**	0.000**	0.002**
	Lower	53.055	0.000**	0.000**	0.000**	0.029*
60	Upper	62.238	0.000**	0.000**	0.000**	0.000**
	Lower	56.79	0.000**	0.000**	0.000**	0.046*
[a]No statistically significant difference, * p < 0.05, ** p < 0.01						

Discussion

In the American Orthodontics upper archwires, the differences found in the anterior part (10 mm) may favor treatment if expansion is needed, since the difference entailed a 2-mm size increase. A contraction of 1 mm to 2 mm was found at 50 mm and 60 mm between the 0.012 archwire and the 0.014 and 0.016 ones; these differences may not affect treatment as they are in the posterior section.

In the American Orthodontics lower archwires, a slight contraction was found at 20 mm in the 0.014 and 0.016 archwires compared to the 0.012 one. In the posterior part, there was also a contraction of the archwire shape at 50 mm; at 60 mm, the 0.014 archwire was larger than the others by 10 mm.
The TD Orthodontics archwires showed a contraction of 1 mm in the 0.016 archwire at 10 mm, 30 mm, 40 mm, 50 mm and 60 mm, compared to the 0.012 and 0.014 archwires. There is a slight contraction in the lower archwire at 10 mm in the 0.014 and 0.016 archwires compared to the 0.012 one; and at 20 mm, the 0.014 and 0.016 archwires were found to be larger than the 0.012 one. The contraction found in the archwires was 1 mm in the upper and lower measurements; in the lower section, the expansion can favor orthodontic treatment.
As for the OrthoPremium brand, on the upper archwire and at 10 mm, a 1-mm contraction on average was found in the 0.016 archwire; at 50 mm and 60 mm, the 0.014 archwire was smaller than the 0.012 and 0.016 ones. The lower archwires showed contractions of 1 mm to 2 mm in the 0.014 and 0.016 archwires compared to 10 mm to 40 mm in the 0.012 archwires; at 50 mm and 60 mm, the 0.012 archwires are smaller than 0.014 and 0.016 archwires.
In the NiTi archwires, the front has a greater increase in the archwire width[11]. In this study, only the AO upper archwire showed expansion in the anterior part as the wire caliber increased; a slight contraction was found in the other brands.
In their 2010 study, Oda et al. found that preformed NiTi archwires can be narrow at the canine and molar levels. Therefore, they state that it would be advisable to increase the size of the archwires from 1 mm to 3 mm in the canine area and from 2 mm to 5 mm in the molar area[12]. In this study, most NiTi archwires presented contraction as the wire caliber increased, so we agree with Oda that the shape of the wire should be broader.
Lee et al. found that the depth in the archwire of the second molars was 37 mm in the maxilla and 33 mm in the mandible[13]. Ferro et al. conducted a study where the molar depth was 34 mm in the maxilla and 30 mm in the mandible[14]. Ahmed et al. reported a 40 mm second molar depth[15]. Hedayati et al. found a molar depth of 27 mm[16]. In this study, most cases of contraction of the archwires were found at 50 mm and 60 mm. This may have no clinical impact since in studies measuring the depth of the dental arch, the second molars are located between 37 mm and 40 mm, unless a third molar were to be treated with orthodontics.
When comparing the archwires of the three companies, we found very few coincidences, so it would not be advisable to use a combination of

brands during treatment. These results match those of Braun et al., although their research was conducted on rectangular NiTi archwires[11].

Conclusions

There are differences in the sizes of both the upper and lower archwires in each brand. The brand with the least differences among its archwires was American Orthodontics; the difference in the upper archwire was a 2-mm expansion at 10 mm, between the 0.012 archwire and the 0.014 and 0.016 archwires. It is not advisable to use NiTi archwires from different brands on the same patient as the size may vary by brand.

Authorship contribution

1) Conception and design of study
2) Acquisition of data
3) Data analysis
4) Discussion of results
5) Drafting of the manuscript
6) Approval of the final version of the manuscript.

X.G. has contributed in 2,4,5,6.
J.F. has contributed in 1,3,4,5,6.
M.P. has contributed in 1,5,6.

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