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How suited are the different commercially available archwires for the Egyptian dental arches?

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ABSTRACT

Background: The purpose of this study was to investigate the suitability of the widths of some commercially available preformed NiTi arch wires to the dental arch widths of a sample of the Egyptian population.
Methods: This cross-sectional study included 420 maxillary and mandibular pairs of casts for subjects with an age range of 10-16 years as part of project by the National Research Centre. The casts were traced using TracerNet; intercanine and intermolar widths were measured on the casts. Anterior and posterior arch lengths were measured to facilitates the measurements on the wires. The intercanine and intermolar widths of eight commercially available archwires were measured on a graph paper.
Results: Regression analysis was performed to create a regression model for the predicted means of the intercanine and intermolar widths in different age groups. The mean square error (MSE) was calculated for all the available arch wires in relation to the dental arch. Ormco (Broad arch/small) had the lowest MSE; 1.55 for the upper intercanine width and 1.72 for the upper intermolar width. For the lower intercanine width its MSE was 0.30 for the Ormco and 0.31 for Ortho Technology, while for the lower intermolar width it was 0.78 for Ormco.
Conclusions: The commercially available archwires were all considerably larger than the mean dental arch size of the majority of the population, except for the Ormco; thus, inviting potential relapse of treatment. It is necessary to produce a wider range of customized archwires that better suit the dental arch sizes of the Egyptian population.

Keywords: Relapse, Stability of intercanine width, Stability of intermolar width, Best fit arch, Arch form.
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INTRODUCTION

The stability of the orthodontic treatment outcome has been the debate for many years. It is argued that one of the factors involved in relapse was the change in inter-canine width by treatment[1,2] and that it is considered one of the essential parameters in orthodontic treatment planning when long term stability was concerned.[3]

The improper selection of the initial archwire dimensions used in treatment increases the long-term relapse probability, especially in the mandibular arch.[4] Uhde et al.[5] reported relapse towards the original values when the inter-canine width was increased during treatment, which was not related to the type of treatment, whether extraction or non-extraction.[6]

There appears to be a constant, statistically supported belief throughout the literature that the mandibular inter-canine width, in specific, should not be violated.[7-14] Recurrent crowding and periodontal damage occur when the improper selection of archwire dimensions increases the inter-canine width.[15,16]

Preformed NiTi archwires are usually used; their superelastic properties make adaptation and bending impossible. To our knowledge, none of the available studies in the literature has estimated the relationship of inter-canine and intermolar widths, of commercially available archwires, to those of dental arches in the Egyptian population. On the contrary, other research has investigated the arch form of the commercially available archwires and their compatibility or best fit with the arch forms of different populations.[17-20] Early in 1965, Aitchison[21] recognized that different ethnic groups exhibited different arch shapes and sizes. Othman et al.[22] on the other hand, reported that Malays and Malaysian Aborigines were similar in their arch dimensions and shapes, which implies that similar or closely related ethnic backgrounds could have similar dental characteristics.

Accordingly, the purpose of this study was to investigate the suitability of the widths of some commercially available preformed NiTi archwires to the dental arch widths of a sample of the Egyptian population.

METHODS

This cross-sectional study included 420 maxillary and mandibular pairs of dental stone casts that were randomly selected from the dental casts of school children at Al-Fayoum Governorate; collected as a part of a project by the National Research Centre. The casts were of subjects with an age range of 10-16 years. The selection criteria included: any class of malocclusion, no or minimal crowding of 2-3mm, no apparent skeletal malocclusion, intact,

complete set of permanent dentition, the absence of restorations or any missing teeth, and the absence of rotations.

The casts were traced using TracerNet (Nile Delta Co., version II) after capturing photographs of the casts and importing them to the software.[23] Calibration in the vertical and horizontal dimensions using a millimeter ruler was done. When the magnification of the ruler in the two axes is known, the cast magnification can be determined. Maximum accuracy was achieved when the two scales were perpendicular. The points needed for every measurement were marked by two well-trained operators and the software automatically determined the measurements in millimeters. Eight commercially available different brands of NiTi wires were used for the study (Table 1)

The measurements taken on the casts using the software program, as follows (Figure 1):

Inter-canine width (ICW): the distance between the cusp tips of the canine in the maxilla (U33) and the mandible (l33).

Intermolar width (IMW): the distance between the mesiopalatal cusp tips of maxillary first permanent molars (U66). The distance between the mesiobuccal cusp tips of mandibular first permanent molars (l66).

Anterior arch length (AAL): the perpendicular distance from the midline to a line drawn between the cusp tip of mandibular canines and similarly on maxillary canines.

Total arch length (TAL): the perpendicular distance from the midline to a line drawn between the mesiopalatal cusp tips of maxillary first permanent molars and similarly in the mandible.

The AAL and TAL measurements were taken to facilitate the measurements of the inter-canine and intermolar widths of the wires.

The measurements were taken on the archwires (Figure 2):

Wire inter-canine width (WICW): Two lines were drawn on graph paper according to the average of the measured AAL and TAL of the casts. A line representing the ICW and another perpendicular to it have the same length as the average AAL. The wire was taped such that its midline coincided with the perpendicular line. The ICW of the wire was then measured on the paper ICW line.

Wire intermolar width (WIMW): similarly, the intermolar width of the wire was measured using the measured average IMW from the casts.

Table 1. The commercially available archwires used.

0.016" NiTi wires	Manufacturer specifications
American Orthodontics	NT3, SE NiTi archwire, American Orthodontics
Ortho Organizers	Arch shape archwire, Nitanium® Super Elastic Pro Form™, Ortho Organizers, Inc, CA, USA
IOS	Natural form, Super Elastic NiTi archwire, International Orthodontic services, USA
Ormco	Broad arch/small, Ormco Corporation, CA, USA
Ortho Pro	Alpha wire, Super Elastic NiTi archwire, Ortho Pro Dent, LLC, FL, USA
Ortho Technology	TruFlex™ NiTi archwire, Ortho Technology, Inc, Florida, USA
Modern	Natural form, TiNol-1 Super Elastic NiTi, Modern Orthodontics, LLC, CA, USA
Chinese	Super Elastic NiTi archwire, China

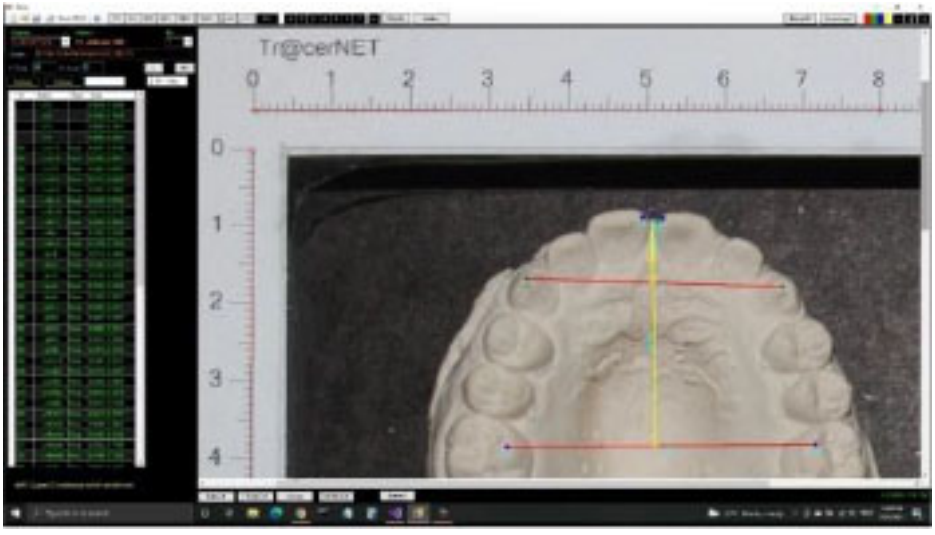

Figure 1. TracerNet cast measurements.

Statistical method

Descriptive statistics, including means and standard deviations for U33, U66, l33, and l66, were used to describe each age group. T-test was used to compare males and females. Regression analysis was used to investigate the effect of age on the four variables, and then those regression equations were used to predict each age group means. The predicated means and the pooled variance were used to construct the normal distribution curve for the four variables.

To assess the usability of different wire types in the Egyptian population, mean square error deviations were calculated for each wire type (W) as follow:

$$MSE = \frac{\sqrt{\sum_{i=10}^{16}(W - X_i)^2}}{No.\,of\ age\ groups}$$

Where Xi =the predicted mean at age i

Statistical analysis was done by PASW Statistics 18 package. Charts and MSE were constructed by using Microsoft Excel.

The reproducibility of the cast measurements was determined by randomly selecting 20 casts from the sample. The measurements were repeated by the same operators (Intra-examiner error) and two different operators (inter-examiner error). Similarly, the reproducibility of the measurements

done on the wires was determined. The deviation of measurements, in either case, fell within the accepted range of accuracy (3%-5%) as was proven statistically by the calculation of the mean and the standard deviation of the measurements taken.

RESULTS

Descriptive statistics for the upper and lower inter-canine width (U33, l66; respectively) and intermolar width (U66, l66; respectively) in each age are shown in Table 2. There was no significant difference between males and females for the inter-canine width or the intermolar width; p<0.05, as shown in Table 3.

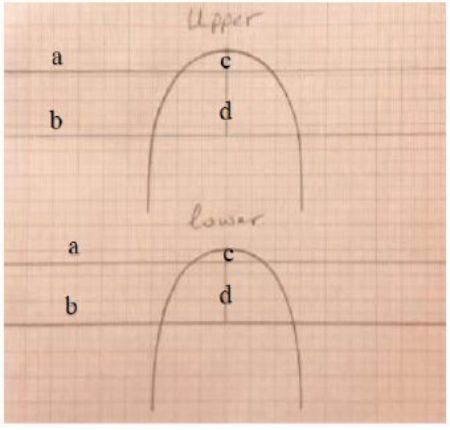

Figure 2. Archwire measurements. a: Wire inter-canine width (WICW), b: Wire intermolar width (WIMW), c: Anterior arch length (AAL), d: Total arch length (TAL).

The regression analysis of the effect of age on the upper and lower inter-canine and intermolar widths were significant; p<0.05 (Table 4).

Based on this regression model, the predicted mean of all the variables was calculated and displayed in Table 5.

The mean square error (MSE) of the investigated upper archwires regarding the inter-canine width in relation to the population mean was observed to be 1.55 for the Ormco archwire, 2.37 for Ortho Pro and Ortho Technology, 3.77 for Ortho Organizers, 4.04 for the Chinese wire, 5.23 for IOS, 5.72 for American Orthodontics and 6.21 for Modern. The normal distribution curve of U33 in relation to different wires shows that the available wires covered mostly half the means of the sample, while the other half was not well covered; i.e., the means 25-30, 30-35 and 40-45 were not covered by any of the wires (Figure 3).

As for the upper intermolar width, it was 1.72 for Ormco, 12 for the Chinese wire, 12.49 for Ortho Pro and Ortho Technology, 12.99 for American Orthodontics and Ortho Organizers and 13.99 for IOS and Modern archwire; which shows that all the archwires except the Ormco were outside the normal range of the sample, Figure 3.

In the lower arch, the MSE of the wires concerning the inter-canine width in relation to the population mean was as follows; Ormco, 0.30; Ortho Technology, 0.31; Ortho Organizers, 0.54; American Orthodontics and Ortho Pro, 0.91; Modern and Chinese, 1.30 and IOS, 1.70. The normal distribution curve of l33 in relation to different wires shows that the available wires covered mostly half the means of the sample, while the other half was not well covered; i.e., the means 19-27 and 31-35 were not covered by any of the wires; Figure 3.

While for the lower intermolar width, the MES was 0.78 for Ormco archwires, 4.01 for Ortho Organizers and Ortho Technology, 4.21 for Modern, 4.42 for Ortho Pro, 4.62 for IOS, 4.82 for American Orthodontics and 6.05 for Chinese archwires; which shows that all the archwires except the Ormco were outside the normal range of the sample.

DISCUSSION

Orthodontists, along the ages, have always strived to obtain a stable orthodontic treatment. The stability of the treatment outcome has been related to many parameters and variables, among which are the inter-canine and intermolar widths, which were the subject of investigation in the past decades.[24,25] It was reported that the inter-canine width would remain relatively stable if it was not changed by treatment.[26-28] Bishara et al.[29] concluded that relapse of the inter-canine width was inevitable when changed by treatment.

Table 2. Mean, median and standard deviation of U33, U66, l33 and l66.

	U33		U66		l33		l66	
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD
10	31.73	3.39	44.64	6.23	26.17	2.99	40.52	4.51
11	27.49	3.23	38.93	5.25	22.65	3.15	36.04	1.13
13	33.88	2.80	46.24	2.37	27.48	2.02	41.86	1.88
14	35.50	1.45	47.55	3.50	28.49	1.36	43.91	2.29
15	35.73	3.86	47.21	5.91	28.99	3.01	42.13	3.63
16	34.08	1.05	46.00	2.91	23.90	0.35	40.06	2.44
Total	33.87	3.12	45.98	4.15	26.99	2.66	41.78	3.21

Table 3. T-test to compare males and females.

	U33		U66		l33		l66	
Gender	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males	34.39	3.27	46.61	4.41	27.78	2.66	42.67	2.89
Females	33.08	2.84	45.04	3.75	25.80	2.30	40.44	3.33
P-value	0.312 ns		0.365 ns		0.067 ns		0.089 ns	

ns; non-significant p<0.05

Adamek et al.[3] in 2015 also reported in their literature review that maintaining the original inter-canine and intermolar widths was critical for the stability of treatment.

When the archwires were concerned, research always focused on the arch form and the distribution of different arch types among a population,[17-20,22,30,31] however; the relation between the width of the initial archwire and the arch width as a potential factor for the stability of treatment in the Egyptian population was not addressed before.

Two new methods were devised during this investigation; the first one was employed to correctly measure the inter-canine and intermolar widths on the wires based on the mean dental inter-canine and intermolar widths of the studied population. The second method was advocated to overcome the sampling errors by making a statistical regression analysis for the effect of age on the different variables, which was significant. This phenomenon facilitated the prediction of the mean inter-canine and intermolar widths for each age group to investigate the distribution of the available wires over the population. Furthermore, the mean thickness of the bracket base was taken into consideration to mimic clinical conditions closely.[17,20]

On comparing the measurements of the different commercially available wires to the predicted mean of the population, it was found that the Ormco (Broad arch/small) archwires had the lowest mean square error for the upper inter-canine and intermolar widths, 1.55 and 1.72; respectively. They also had the lowest mean square error for the lower ICW and IMW, 0.30 and 0.78, respectively. They indicated that the tested Ormco (Broad arch/small) archwire closely matched a wider scale of the population arches, yet the lower Ortho Technology archwire strictly followed the Ormco (Broad arch/small) archwire in the inter-canine width; having a mean square error of 0.31, but not in the intermolar width. On the other hand, the distribution of wires over the population showed that some areas were lacking and that there were no commercially available wires to fit some sections of the population.

There was no significant difference between males and females for the inter-canine width or the intermolar width, which concurred with some studies[20,22,32,33] however; it was in contrast with the findings of other researches where female arch dimensions were smaller than males.[3,25,30,34] These contradictory reports could have resorted to variations in the sample size and the race.[3,16,20]

The ethnic variation plays an important role that must not be overlooked in the shape and size of the dental arch[2,16] and hence; the archwire sizes. Lombardo et al.[35] studied the dental casts of southern Europeans compared to the commercially available archwires and found that none of the available wires represented the ideal dentition they calculated. Studying the Japanese population, Oda et al.[36] observed that the preformed archwires were narrower than the normal dental arches, with the Orthos (Ormco, Glendora, Calif) and Vari-Simplex large (Ormco) types having the best fit arch form. On the contrary, when Africans and Caucasians were compared, it was reported that the Africans had wider and longer dental arches and that the range of market available wires didn't suit the anatomical variability of patients.[35] When the Iranian population was investigated, it was noticed that most of the available archwires were wider than the average normal dental arches.[37] Moreover, Bayome et al.[18] compared Egyptians to North American White populations and noted that Egyptians had narrower arch forms. This fact is in line with the findings of our research, showing that all of the available archwires were wider than the

Table 4. **Regression model for the effect of age on the different variables.**

variable	R^2	Constant	Increment/ year in mm	p
U33	0.359	27.15	0.51	0.000*
U66	0.145	40.44	0.43	0.011*
I33	0.224	22.39	0.34	0.000*
I66	0.209	36.08	0.43	0.001*

*; significant at p<0.05

Table 5. **The predicted mean of each variable for age groups 10-16 years.**

Age	U33	U66	I33	I66
10	32.27	44.69	25.82	40.36
11	32.78	45.12	26.16	40.79
13	33.80	45.97	26.85	41.65
14	34.31	46.39	27.19	42.08
15	34.83	46.82	27.53	42.50
16	35.34	47.24	27.88	42.93

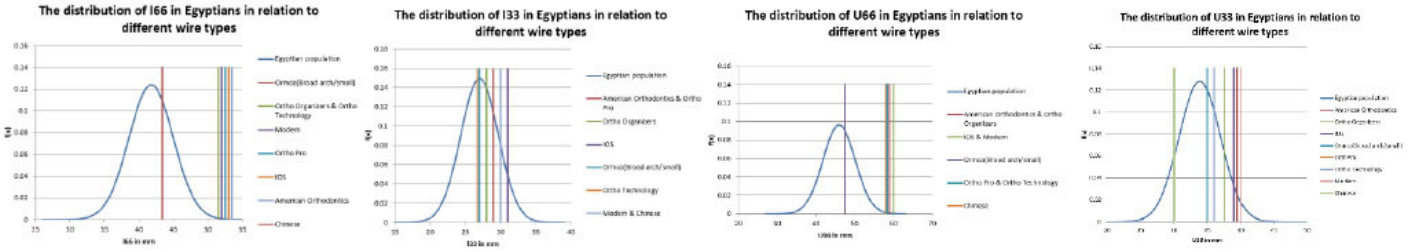

Figure 3. Normal distribution curves, showing the distribution of the population means in relation to the available wires.

dental arch sizes with high mean square error, except for the Ormco (Broad arch/small) archwire, which had the closest size with the least mean error; yet not the perfect fit. This could be attributed to all the investigated wires having the same manufacturing origin, except for the Chinese. The industry usually fabricates wires according to a given population.[20]

The arch dimensions are dynamic parameters that never stop changing by age but decline with minor changes during adolescence.[3,38] Carter and McNamar[39] stated that treatment changes in inter-canine width of less than 0.50mm over 30 years would be clinically insignificant. Based on this hypothesis, it could be mentioned that the available archwires, except for the Ormco (Broad arch/small), can considerably change the anterior and posterior arch widths when used as initial wires during leveling and alignment; which invites potential relapse after treatment. In light of this information and within the limitations of this study, the manufacturing and provision of customized archwires for the different segments of the population and closely matching populations could be recommended.

CONCLUSIONS

The commercially available archwires were all considerably larger than the mean dental arch size of the majority of the population, except for the Ormco (Broad arch/small); thus, inviting potential relapse of treatment. The available wires do not cover the entire normal range of the population. Hence, it is necessary to produce a broader range of customized archwires that better suit the dental arch sizes of the Egyptian population.

CONFLICT OF INTEREST

All authors declared that there is no conflict of interest regarding the publication of this article.

ETHICAL APPROVAL

The Medical Research Ethical Committee approved the study of the National Research Centre, reference number: (16-343).

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AUTHOR CONTRIBUTION

All authors contributed equally in the research process, manuscript writing, and revision.

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