Original Article / Özgün Araştırma

Comparison of the Nickel Titanium Alloy Archwires' Dimensions with the Mean Arch Dimensions of a Turkish Sample

Nikel Titanyum Alaşımı Ark Tellerinin Ark Boyutlarının Türk Örneklem Grubunun Ortalama Ark Boyutları ile Karşılaştırılması

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Abstract

Objective: This study aimed to evaluate the harmony between the mandibular arch dimensions of a Turkish sample that has Class I occlusion without orthodontic treatment history and the arch dimensions of archwires produced by different manufacturers.

Materials and Methods: Mandibular dental casts were fabricated from 40 individuals with dentoskeletal Class I relationships, with minimal crowding. Dental casts were reduced to two dimensions using a photocopy machine, the intercanine distance, canine depth, intermolar distance and molar depth was recorded. The same parameters were measured in 8 rectangular archwires (named from A to H) marketed by 5 manufacturers and the measurement differences were compared.

Results: The archwire whose intercanine distance was the most suitable for the arch dimensions of the individuals in the study group was arch B, and the archwire with the most suitable intermolar distance was arch A. When the intercanine and intermolar distances were evaluated together, the archwire most compatible with the data of the individuals in the study group was arch A. The archwire that was the most incompatible with the arch dimensions of the individuals in the study group was arch D.

Conclusion: Differences were observed between the arch dimensions of all archwires evaluated in the study and the arch dimensions of the individuals in the study group. It may be advisable to take this finding into consideration in the maintenance of the orthodontic treatment results.

Öz

Amaç: Bu çalışmanın amacı ortodontik tedavi görmemiş, Sınıf I oklüzyon gösteren ve ortodontik tedavi geçmişi olmayan Türk bireylerden oluşan bir örneklem grubundan elde edilen mandibular ark boyutları ile farklı üretici firmalar tarafından üretilen ark tellerinin boyutları arasındaki uyumun değerlendirilmesidir.

Gereç ve Yöntemler: Bu araştırma kapsamında iskeletsel ve dental Sınıf I ilişkiye sahip, minimal çapraşıklığı bulunan toplam 40 bireyden mandibular alçı model elde edilmiştir. Ortodontik modeller fotokopi makinesi aracılığı ile iki boyuta indirgenmiş, interkanin mesafe, kanin derinliği, intermolar mesafe ve molar derinliği kaydedilmiştir. Aynı parametreler 5 üretici firma tarafından pazarlanan dikdörtgen kesitli 8 ark telinde (A'dan H'ye kadar isimlendirilmiş) de ölçülerek aradaki fark karşılaştırılmıştır.

Bulgular: Çalışmada incelenen ark tellerinden interkanin mesafenin çalışma grubundaki bireylerin ark boyutlarına en uygun olan ark telinin ark B, intermolar mesafesi en uygun olan ark telinin ise ark A olduğu gözlenmiştir. Hem interkanin hem de intermolar mesafeleri birlikte değerlendirdiğimizde ise çalışma grubundaki bireylerin verileri ile en uyumlu ark telinin ark A olduğu gözlenmiştir. Çalışma grubundaki bireylerin ark boyutları ile en uyumsuz olan ark telinin ise ark D olduğu belirlenmiştir.
Sonuç: Çalışmada değerlendirilen tüm ark tellerinin ark boyutları ile çalışma grubundaki bireylerin ark boyutları arasında farklılıklar gözlenmiştir. Ortodontik tedavi sonuçlarının idamesi konusunda bu bulguların dikkate alınması tavsiye edilebilir.

Introduction

The Straight Wire technique was developed by Lawrence Andrews and the brackets' design changes have made it possible to use preformed archwires, saving clinicians from time consuming bendings (1).

Many attempts have been made to find a universal arch form that will suit everyone (2,3). However, it is evident that a single arch form is not characteristic of a particular malocclusion and therefore customization of the archwires is accepted as always necessary (4). Archwires in various sizes and shapes are offered to clinicians in the market, and these characteristics closely affect orthodontic treatment results. Studies have shown that maintaining especially the intercanine width, the intermolar width, and the arch length contributes greatly to the stability of treatment results (5,6). A meta-analysis by Burke et al. (7) also emphasized that preservation of the original mandibular intercanine width is crucial for stability, as this distance tends to return to its pre-treatment value. Relapse is also known to occur almost ineluctably when the teeth are placed in an unstable position, outside the functional envelope. There is evidence that the most reliable way to maximize post-treatment stability is to maintain the original, pre-treatment arch form in which the teeth are presumed to be in a stable position (4).

In the ideal conditions, it is recommended to select the archwires individually by evaluating the arch sizes and arch shape. It is possible to bend stainless steel wires and customize both the arc properties. However, in most clinics, the archwires, especially Nickel Titanium (NiTi) archwires, are routinely used in different cross-sectional sizes but in one form. The treatment options in the lower jaw are limited compared to the upper, and the upper arc form is connected to its lower counterpart. Moreover, the lower intercanine distance is a crucial parameter known to be the key for stability of the orthodontic treatment outcomes. Considering all these main points, the use of NiTi archwires with standard shape and size can be problematic, especially in the lower jaw.

According to our literature research, no study has evaluated yet the harmony between the mean arch dimensions of the Turkish individuals and those of the archwires available in the market. The aim of this study is to evaluate the harmony between the mandibular arch dimensions of the best-selling archwires from different manufacturers and the mandibular arch dimensions obtained from Turkish individuals presenting Angle Class I occlusion with no orthodontic treatment history. We aimed to determine the wire that shows the best compatibility with the mean arc dimensions. As the null hypothesis, we suggested that there would be no difference between the selected archwires dimensions and the mean arch dimensions of the sample.

Materials and Methods

This clinical study was approved by Bezmialem Vakıf University Non-Invasive Ethics Committee (approval number: 54022451-050.05.04 date: 27.02.2018). The difference of 2.62 mm between the preformed and natural arch dimensions for the intermolar distance in the study by Oda et al. (8) was accepted as 3 on average. At least 35 cases were necessary to work with 95% confidence interval and to obtain 80% power for the present study.

Twenty female and 20 male volunteers who had not received any orthodontic treatment and who presented crowding less than 3 mm participated to the research and signed the informed consent form. They all presented Class I dentoskeletal relationship, and the ages ranged from 20 to 25. All the volunteers were in permanent dentition, had no missing, restored or impacted tooth, they all had ideal overjet-overbite, none of them had significant asymmetry and any craniofacial syndrome. The records of the individuals included in the study were collected in Bezmialem Vakıf University Faculty of Dentistry, Department of Orthodontics between April 2018 and May 2019.

Alginate impressions taken from the lower jaw were poured with hard plaster immediately after the procedure and special care was taken to leave no air bubbles. Two dimensional copies of the models were created using a printer with scanning feature (Develop Ineo4050).

In the study of Oda et al. (8), the buccolingual thickness of the central and canine brackets and those of molar tubes with 0.022-inch slot from 8 different manufacturers, were recorded and the average bracket and tube thicknesses were determined. We took reference from Oda et al.'s (8) average attachment thicknesses for central incisors, canines and first molars that are 1.34 mm, 0.75 mm and 0.73 mm respectively. The mean attachment thicknesses were added perpendicularly to the midpoints of the vestibular surfaces of the teeth in the mesiodistal direction on the 2-dimensional copies following the method described by Oda et al. (8). The bracket slot point (BSP), that is the surface where the archwire is likely to pass, was determined accordingly (Figure 1). The intercanine and intermolar distances were recorded at the BSP level (Figure 1). In addition, the canine and first molar depths were measured considering the BSP of the central tooth and finally, the mean arch dimensions were calculated.

While selecting the archwires, the local distributers of the manufacturers were interviewed and the best-selling products on the market were chosen. Eight different archwires from five manufacturers were selected for size analysis (Table 1).

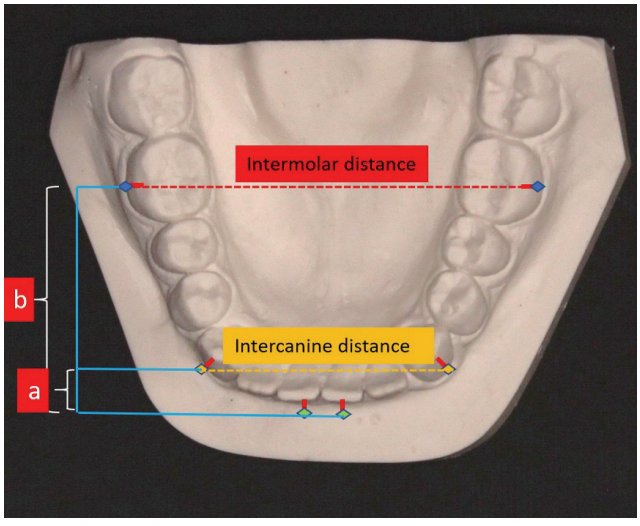

Figure 1. Bracket slot points at the central, canine and molar levels, intercanine and intermolar distances, canine (a) and molar (b) depths

Measurements on the arc wires included in the study were carried out on millimetric graph paper. The midline of the wires was overlapped with the midline determined on the graph paper, and the intercanine and intermolar distances were measured according to the mean canine and molar depths recorded (Figure 2).

Statistical Analysis

The comparative statistics were not applicable. The mean values, the standard deviations and the delta values were calculated with Microsoft Excel (Microsoft Windows, USA).

In order to determine measurement errors, half of the randomly selected study models were remeasured 2 weeks later by the same examiner (B.Y.). The Wilcoxon signed-rank test was performed to assess the difference between two measurements. Additionally, the dimensions of the preformed archwires at the canine and first molar levels were graphically compared with means of normal dental arch widths.

Results

Based on the measurements, the mean canine depth and the intercanine distance at BSP were recorded as 6.08±0.70 mm and 29.67±1.56 mm respectively. All the measurements were performed by an orthodontist (B.Y.) with 7-8 years of experience and no statistical difference was noted between the repeated measurements (p=0.65). The graphical comparison of the intercanine dimension of the

Table 1. Archwires whose dimensions were evaluated in the study

Arch shape	Manufacturer
Europa II (arch A)	RMO (Denver, USA)
Bioform III (arch B)	RMO (Denver, USA)
Trueform I (arch C)	RMO (Denver, USA)
Damon (arch D)	Ormco (Glendora, Calif, USA)
Natural (arch E)	Highland Metal (Franklin, USA)
Form A (arch F)	GC Orthodontics (Breckerfeld, Germany)
Form III (arch G)	American Orthodontics (Sheboygan, USA)
VLP (arch H)	American Orthodontics (Sheboygan, USA)

cast measurements and the archwires is presented in Figure 3. Among the archwires that we evaluated in terms of intercanine distance, the most suitable archwire was found to be arch B (28.91 mm) (Figure 3). The second closest dimension was measured with arch E (30.44 mm). The archwire that presented the most incompatible dimension with the average intercanine distance of the study group was arch D (34.68 mm). It is noteworthy that the intercanine distances of the archwires evaluated in this study were larger than the mean intercanine distance of the Turkish individuals who participated in this study except one archwire (arch B) (Figure 3, Table 2).

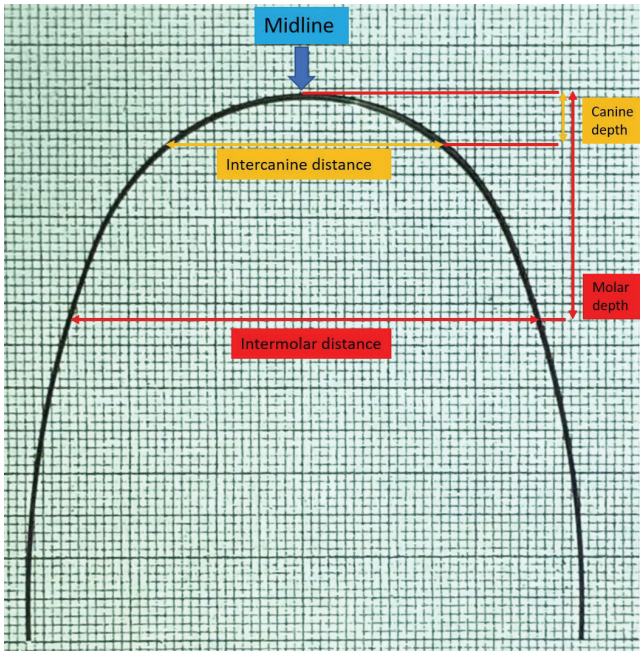

Figure 2. Measurement of the arch dimensions of a Damon (Ormco) archwire on graph paper

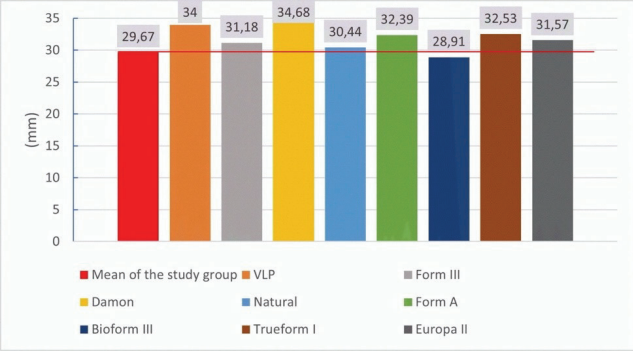

Figure 3. Intercanine distances (mm) of different archwires measured at mean canine depth

Measurements of individuals included in the study showed an average molar depth of 26.85±1.56 mm and a mean intermolar distance of 52.35±2.00 mm at BSP. The graphical comparison of the intermolar dimension of the cast measurements and the archwires is presented in Figure 4. Among the archwires we evaluated, the most suitable archwire in terms of intermolar distance was found to be arch A (52.26 mm) followed by be arch G (51.11 mm) (Figure 4). The most incompatible archwire for the intermolar distance was arch D (57.65 mm), like the intercanine distance. We also remarked that the intermolar distance of most of the archwires was narrower than the mean intermolar distance of the individuals (Figure 4, Table 2).

The delta (Δ) values of the intercanine and intermolar distances are presented at Table 2. Considering the archwires in terms of intercanine and intermolar distances at BSP, we found that the most compatible archwire with the mean values was arch A, followed by arch G (Table 2) (sum of the absolute difference values). Arch D was determined to be the most incompatible archwire in terms of intercanine and intermolar distances.

Discussion

NiTi archwires are preferred especially during the initial stage of the treatment since they have great superelastic and shape-memory properties. However, it is not possible to customize their form nor their dimensions. It has been reported that, the heavier NiTi archwires are more capable of changing the intercanine width during alignment and should be used with attention (9). Thus, by choosing the most appropriate NiTi archwire from the early stages of the treatment, the patient's chair time can be reduced by necessitating less customization when switching to stainless steel archwires. Moreover, clinicians try to choose the best fitting archwire to the original arch form and size of the patient to achieve a stable treatment outcome preserving the initial intercanine distance (10).

In the present study, we aimed to compare the arch dimensions of 8 different preformed archwires with the arch dimensions of a Turkish sample, to determine the most suitable archwire among the most popular ones on the market. The reason why the study was based on individuals presenting naturally the ideal

Table 2. The intercanine and the intermolar distances of the study group and the archwires

Arch shape	Intercanine distance	Intermolar distance	ΔIntercanine distance	ΔIntermolar distance
Europa II (arch A)	31.57	52.26	+1.90	-0.09
Bioform III (arch B)	28.91	48.10	-0.76	-4.25
Trueform I (arch C)	32.53	50.23	+2.86	-2.12
Damon (arch D)	34.68	57.65	+5.01	+5.3
Natural (arch E)	30.44	46.93	+0.77	-5.42
Form A (arch F)	32.39	51.05	+2.72	-1.30
Form III (arch G)	31.18	51.11	+1.51	-1.24
VLP (arch H)	34.00	55.93	+4.33	+3.58
Mean values recorded with the study group	29.67±1.56 mm	52.35±2.00 mm	-	-

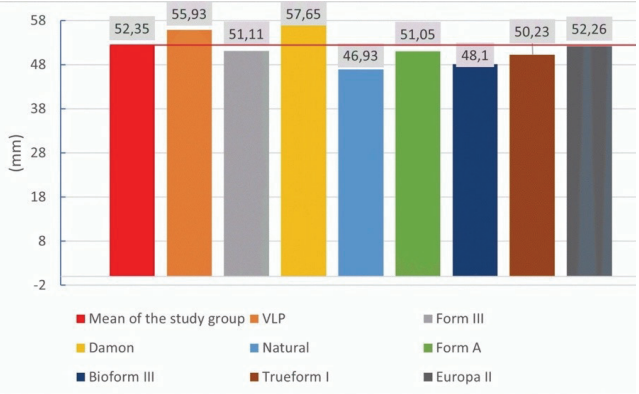

Figure 4. Intermolar distances (mm) of different archwires measured at the mean molar depth

occlusion is that the most common final goal of the orthodontic treatment is to achieve Class I occlusion.

Following the method of a similar previous study, we evaluated only the mandibular arch (8). The final occlusal relations are often planned based on the lower canine position since the therapeutic procedures in the mandible are more limited compared to those possible for the maxillary dentition. Thus, the maxillary arch form is strongly associated with the mandible and maintaining original mandibular canine width is an essential element in post-treatment stability (4,7,10).

In a study evaluating clinicians' choices when selecting archwires, NiTi archwires (99%) were preferred as the initial alignment wire (11). Although many clinicians stated that preservation of the intercanine width is particularly important, they stated that preservation of the pretreatment arch form was essential in the later but not in the early stages of the treatment (11). However, the results of the study revealed that there is no conformity about how the arch form should be preserved. The authors concluded that even when clinicians desire to adapt their archwires with the intention of preserving the original arch form, the methods that they use is questionable.

The arch dimension and the arch form are considered as two essential factors in terms of teeth alignment, achieving esthetic results, and establishing occlusal stability (12). The effects of different variables on the arch size and form such as age, sex, malocclusion type and ethnicity have been previously evaluated (13-16). Bishara et al. (13) stated that the mandibular intercanine width increases until 13 years of age, but this dimension, on the average, was established by 8 years of age. On the other hand, the mandibular intercanine dimension is found to decrease slightly after 13 years of age. They reported that the decrease was significant only between 26 and 45 years of age and that the change in the intermolar width is not significant between 13 to 26 years of age. Therefore, we included individuals aged between 20 to 25 years in our study.

There are studies reporting contradictory results about the impact of the sex parameter on the arch size (13,15,17). We included equal numbers of male and female individuals to minimize the bias related to gender differences.

Nowadays, most of the manufacturers produce their archwires based on American or European arch forms. In a study comparing the arch forms of Turkish and North American individuals, it was reported that North Americans have greater molar depth and lower

molar width/depth ratio in comparison to the Turkish individuals, however, no significant difference was found for the transverse widths at the canine and molar levels between groups. The authors also stated the most frequent arch form seen was the ovoid arch form among the Turkish individuals and the tapered form was more common in the White American group (16). In another study by Nojima et al. (14), significantly larger width measurements at the canine and molar levels were recorded with the Japanese individuals compared to a group consisted of North American Whites, and the anteroposterior length to canine and molar widths ratios were also found to be greater for the Japanese individuals. In harmony with those findings, Kook et al. (18) reported larger and wider dental arches in a Korean population in comparison to a group consisted of White Americans and they stated that most of the preformed archwires are too narrow for many Asian patients. Similarly, it was reported that the commercially available preformed archwires had narrower widths at both canine and molar levels compared to the mean values recorded with a Japanese population (8). The preformed archwires that closely matched the mean arch dimensions were Orthos and Vari-Simplex (Ormco, Glendora, Calif, USA) large types. We referred to the mean average bracket and tube thickness calculated by Oda et al. (8) but we did not evaluate the same archwire brands since we selected the archwires based on the commercial data provided by the local providers. Unlike Oda et al.'s (8) results, all examined archwires were wider at the canine level compared to the mean value obtained from individuals in our study group. In contradiction, most of the evaluated archwires were narrower at the first molar level compared to the mean intermolar measurements value. This difference may be explained with ethnic differences. The intercanine distance being narrower, and the intermolar width being larger than the archwires dimensions may be related to the ovoid arch form that is common among Turks as previously reported (16).

The selection of the archwires was based on the reports of the local providers. A further study may evaluate a larger number of archwires from different manufacturers with various shapes. We suggested the fabrication of the archwires is a standard process and we measured one sample of each brand. This is the reason why the lack of a statistical analysis may be considered as a limitation of the study design, but instead of a statistical comparison, a graphical comparison was provided.

The sample of this study consisted of individuals presenting Class I occlusion without orthodontic treatment history, but since there are heterogeneous ethnic backgrounds in the Turkish population, it may be needed to perform further investigations in a larger sample size of people to be able to make a more accurate clinical assumption. In addition, it will be beneficial to carry out further studies to determine the most suitable arch form and size for different genders and different malocclusion types for the Turkish population. Moreover, we believe that the use of three-dimensional technologies could be useful to determine a more precise BSP since they provide a more accurate visualization and control of the tooth surface.

Conclusion

The important conclusions drawn from the present study are as follows:

1. The all examined archwires had larger dimensions in comparison with the mean of the study group at the canine level, whereas most of the evaluated archwires were narrower at the first-molar level.

2. Europa II (RMO, Denver, USA) was the archwire presenting the closest dimensions to the mean widths both at the canine and the molar levels among the evaluated archwires. One the other hand, the most incompatible archwire with both canine and molar width means was Damon (Ormco, Glendora, Calif, USA).

The null hypothesis was rejected. Clinicians are advised to consider these findings in the selection of NiTi archwire whose shape cannot be customized.

Ethics

Ethics Committee Approval: This clinical study was approved by Bezmialem Vakıf University Non-Invasive Ethics Committee (approval number: 54022451-050.05.04, date: 27.02.2018).

Informed Consent: Written consents from participants had taken and kept in files separated for each one.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: B.Ş.Y., Design: B.Ş.Y., S.E., Data Collection or Processing: B.Ş.Y., S.E., Analysis or Interpretation: B.Ş.Y., S.E., E.S.A., K.Y., Literature Search: B.Ş.Y., S.E., E.S.A., K.Y., Writing: B.Ş.Y., E.S.A.

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