R. Ferro*, M. Pasini**, A. Fortini**, A. Arrighi**, E. Carli**, M.R. Giuca**

*Dental Unit, Regional Centre for the Study, the Prevention and the Therapy of Dental Diseases, Cittadella Hospital Health District n. 15, Veneto Region, Cittadella (Padua), Italy
**Department of Surgical, Medical and Molecular Pathology and Critical Care Medicine, Dental Clinic, University of Pisa, Pisa, Italy

email: dr.marcopasini@yahoo.it

DOI: 10.23804/ejpd.2017.18.03.05

Evaluation of maxillary and mandibular arch forms in an Italian adolescents sample with normocclusion

ABSTRACT

Aim *The purpose of this restrospective study was to evaluate the maxillary and mandibular arch forms in an Italian adolescents sample with normocclusion.*
Materials and methods *The dental casts of 106 adolescents (48 females and 58 males; mean age: 14 ± 0.5 years old) were included. Twelve clinical bracket points were measured for each cast and six parameters were evaluated: intercanine and intermolar width, canine and molar depth, canine and molar ratio. Moreover, each cast was classified into tapered, ovoid, or square form. Chi-square test and odds ratio for categorical variables and Student's T-test for continuous parameters were adopted and the level of significance was set at p< 0.05.*
Results *A similar ovoid (43.4%) and tapered (46.2%) arch form was found, while the square form was the rarest (10.4%). Males exhibit higher dental arch values in comparison to females (p< 0.05). Slight variations in maxillary and mandibular intercanine width and canine ratio were observed, while higher variations were seen in the maxillary intermolar width, in the maxillary and mandibular canine and molar depth.*
Conclusion *These results are relevant since individualisation of orthodontic therapy leads to more effective treatment by working within the subject's natural dental arch shape.*

Keywords *Adolescent; Arch form; Caucasian; Dental cast; Occlusion.*

Introduction

The dental arch form evaluation has become an important part of the orthodontic treatment planning. In fact, the study of dental arches is of great relevance to orthodontists and the right choice of orthodontic wires may increase the efficacy of tooth movement, leading to a more stable and natural dentition and decreasing the probability of dental relapse at the end of the orthodontic treatment [Bourzgui et al., 2016]. It is well known that a change in intercanine width, during orthodontic therapy, may represent a predictor of dental relapse and, for these reasons, it is fundamental to maintain the original arch dimension choosing the right arch wire form during the treatment [Housley et al., 2003].

The arch shape is based on anatomic dimension of the alveolar ridge, on tooth eruption and perioral muscles [Triviño et al., 2008]. Moreover, a diversity of dental arch shapes and dimensions in different ethnic groups was observed and several authors proposed geometric models in order to identify the mean configuration of the clinical arch shapes in different populations [Collins and Harris, 1998].

There is a controversy about dental arch configuration among authors using various methodologies [Fujita et al., 2002]. However, most of the studies identified three main arch form shapes: tapered, ovoid and square. Generally, the ovoid dental form is the most commonly used in orthodontic practice (45% of individuals), followed by the tapered form (40%) while the square dental shape is the rarest (15%) [Slaj et al., 2011]. Furthermore, it was stated that a unique arch form cannot provide the best solution for an entire ethnic sample as different dental parameters should be considered; in particular, the main clinical factors that affect the dental arch dimensions are arch depth, cross-arch width and dental perimeter [Bhowmik et al., 2012]. The arch shape consists of two different areas: the anterior curvature and intercanine width and posterior curvature and intermolar width. A preformed arch wire can be customised for each patient adjusting the anterior and posterior curvatures, if necessary. Also, Angle Class represents an important factor that may influence the dental arch shape and it was observed that Class III patients have the most detectable arch form, while Class I patients showed the least detectable arch shape [Slaj et al., 2011]. Concerning the sex differences, on average, males have higher arch dimensions than females [Hajeer, 2014].

The majority of the previous studies showed that the

FIG. 1 Interproximal contact points.

FIG. 2 Clinical bracket points

commercially available dental arch wires were different from the average configuration of the ideal natural occlusion. Lombardo et al. [2013] identified the dental arch shapes representative of the Caucasian population, and found that none of the commercial orthodontic wires examined in their study faithfully represented the shape of the natural occlusion. In literature few studies focus on the dental arch shapes of Italian adolescents with an ideal occlusion. In a recent study, the shape and dimension of the dental arches of 29 subjects of African origin and 37 Caucasian subjects were compared and significant differences between the two ethnic samples were found [Lombardo et al., 2015].

In a previous study, Ferro et al. [2016] evaluated the occlusal traits of 380 adolescents but no information about dental arch form was supplied.

The objective of the present study is to identify the maxillary and mandibular arch shape of Italian adolescents with normocclusion.

Materials and methods

In the present retrospective study, the dental casts of 106 adolescents (48 females and 58 males; mean age: 14 ± 0,5 years old) were randomly selected from a pool of available models at the Cittadella hospital health district dental clinic. Both maxillary and mandibular arches together with a wax bite were included for each patient.

The study was conducted from January to April 2017.

This study was based on an estimated sample size of 96 subjects, which has been calculated to be adequate to achieve 95% of confidence level with a confidence interval of 4 and a standard deviation of 10.

Inclusion criteria were as follows: age between 12 and 15 years, available dental casts, Caucasian and Italian nationality, permanent dentition with normal tooth size and shape, presence of a bilateral Angle Class I molar relationship (in the case of less than a half-cusp displacement, it was considered as a Class I) and 3 mm or less dental arch-length discrepancy. The exclusion criteria were: patients who had received previous orthodontic treatment, craniofacial anomalies or syndromes, medications that may have infuenced the craniofacial growth, anomalies of tooth formation and eruption, presence of restorations extending to contact areas, cusp tips, or incisal edges, presence of monolateral or bilateral cross-bite, overjet > 4 mm, overbite > 4 mm, midline deviation between the two arches > 1 mm.

All procedures were conducted according to the principles expressed in the Declaration of Helsinki and the approval from the local ethics committee was obtained.

Impressions of the dental arches were taken using alginate material.

The occlusal surfaces of the dental casts were photographed, with a ruler included for magnification correction and then were digitised (dimension ratio 1:1).

Dental arch form was evaluated adopting the method of Nojima et al. [2001]; this method was choosen in order to compare our results with those of the international literature [Gafni et al., 2011].

The most facial areas of 13 interproximal contact points (Fig. 1) were estimated to locate the corresponding clinical bracket points. The perpendicular to a line connecting the proximal contact points of each tooth was extended buccally to locate each bracket slot location.

Twelve clinical bracket points (vestibular points at the center of the tooth crown, from first molar to first molar of each side) were measured for each cast (Fig. 2) and six different parameters were evaluated: intercanine width (the measure between the canine clinical bracket points), intermolar width (the measure between the first molar clinical bracket points), canine depth (the measure from a line connecting the canine clinical bracket points to the origin between the central

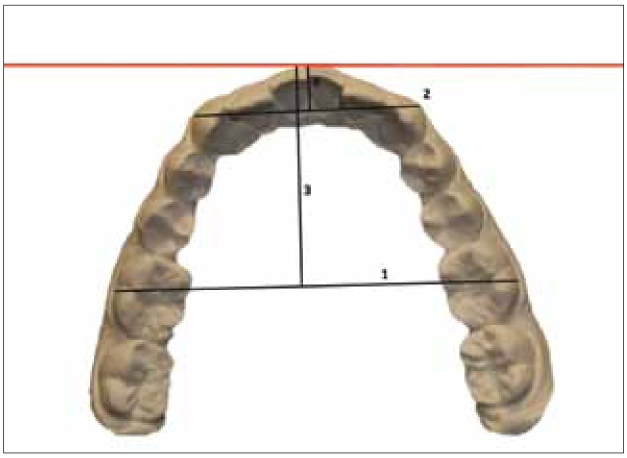

FIG. 3 1: intermolar width; 2: intercanine width; 3: molar depth; 4: canine depth.

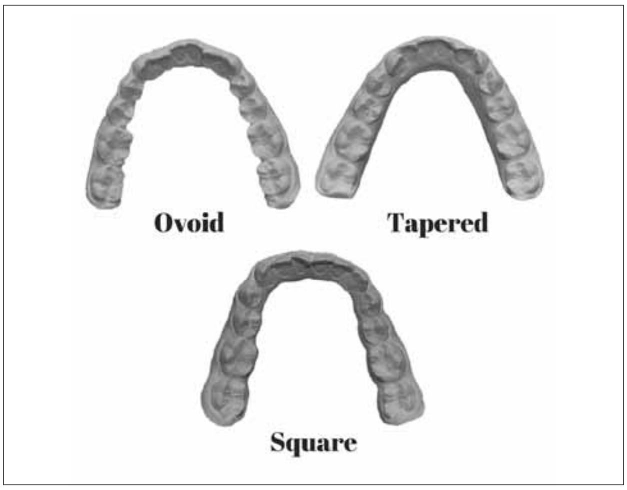

FIG. 4 Tapered, ovoid and square arch form.

incisors), molar depth (the shortest measure from a line connecting the first molar clinical bracket points to the origin between the central incisors), canine ratio (the ratio of intercanine width and canine depth), and molar ratio (the ratio of intermolar width and molar depth) (Fig. 3).

Each dental cast was classified into tapered, ovoid, or square form (Fig. 4) superimposing three templates and then choosing the one that best fit the clinical points and the contact points.

The examination lasted approximately 30 minutes for each dental cast; no radiographs or previous written records were used.

Statistical analysis

All measurements were performed by the same researcher and each measurement was taken to the nearest 0.5 mm. Furthermore, all the variables were measured twice, with a 2-week interval between the two registrations on 50 casts selected at random: intraobserver variability was calculated by using Cohen's Kappa coefficient and the measurements obtained ranged between 0.94 and 0.98.

A second operator measured 50 dental casts and Cohen's Kappa inter-rater agreement was also evaluated: a K coefficient > 0.89 was achieved.

We evaluated statistically significant differences in the prevalence of arch forms by using Chi-square test (categorical variables). Odds ratio (OR) was evaluated and the (95% confidence interval (CI) was used to estimate the precision of the OR.

Student's T-test was used to evaluate the continuous parameters (mean values and standard deviation SD) and the level of significance was set at $p < 0.05$. The statistical analysis was performed with the SPSS (Statistical Package for Social Sciences, Chicago, USA) 22.0 statistical programme.

Results

Dental arch form prevalence

The results of the present study showed that, in the maxillary arch, square form was the less frequent in the sample; a high statistically significant difference (p: 0.001; $p < 0.01$) was observed both in comparison to ovoid (OR: 0.13; CI: 0.06-0.28) and tapered forms (OR: 0.15; CI: 0.07-0.31), while no statistically significant difference (p: 0.68; $p > 0.05$) was found between the ovoid and the tapered arch forms (Table 1).

Also in the lower arch, it was observed that square form was the less frequent in adolescents (OR: 0.24; CI:0.12-0.46) (p: 0.001; $p < 0.01$). The same percentage of ovoid and tapered forms was recorded, and no

	Tapered			Ovoid			Square		
Maxillary Form	Total	Females	Males	Total	Females	Males	Total	Females	Males
Number	46	19	27	49	21	28	11	8	3
Percentage (%)	43.4%	41.3%	58.7%	46.2%	42.9%	57.1%	10.4%	72.7%	27.3%
Mandibular form	Total	Females	Males	Total	Females	Males	Total	Females	Males
Number	45	20	25	45	24	21	16	4	12
Percentage (%)	42.45%	44.4%	55.6%	42.45%	53.3%	46.7%	15.1%	25%	75%

TABLE 1 Upper and lower dental arch shapes.

Dental Arch		Intercanine Width (means ± SD)	Intermolar Width (means ± SD)	Canine Depth (means ± SD)	Molar Depth (means ± SD)	Canine Ratio (means ± SD)	Molar Ratio (means ± SD)
Maxillary	total	37.6 mm ± 2.2 mm	56.4 mm ± 2.9 mm	9.6 mm ± 1.7 mm	33.4 mm ± 2.6 mm	3.9 ± 0.8	1.7 ± 0.2
	males	38.4 mm ± 2.3 mm	57.7 mm ± 3 mm	10 mm ± 1.6 mm	34 mm ± 2.2 mm	3.9 ± 0.7	1.7 ± 0.1
	females	36.8 mm ± 1.9 mm	55.2 mm ± 2.4 mm	9.3 mm ± 1.8 mm	32.9 mm ± 2.7 mm	4.1 ± 0.9	1.7 ± 0.1
Mandibular	total	30.4 mm ± 4.4 mm	54.2 mm ± 7.6 mm	5.7 mm ± 1.2 mm	28.8 mm ± 4.5 mm	5.3 ± 0.9	1.9 ± 0.2
	males	31.2 mm ± 1.9 mm	55.6 mm ± 3 mm	5.9 mm ± 1 mm	29.6 mm ± 2.1 mm	5.4 ±1	1.9 ± 0.2
	females	29.6 mm ± 4.4 mm	52.8 mm ± 7.7 mm	5.5 mm ± 1.3 mm	28.1 mm ± 4.5 mm	5.5 ± 1	1.9 ± 0.2

TABLE 2 Dental parameters in the whole sample with sex distribution.

	Intercanine Width (means ± SD)	Intermolar Width (means ± SD)	Canine Depth (means ± SD)	Molar Depth (means ± SD)	Canine Ratio (means ± SD)	Molar Ratio (means ± SD)
Tapered	37 mm ± 2 mm	56 mm ± 3 mm	10 mm ± 2 mm	34 mm ± 2 mm	3.7 ± 0.6	1.6 ± 0.1
Ovoid	36 mm ± 3 mm	54 mm ± 3 mm	9 mm ± 2 mm	31 mm ± 3 mm	3.9 ± 0.7	1.6 ± 0.1
Square	38 mm ± 6 mm	56 mm ± 9 mm	8 mm ± 2 mm	32 mm ± 5 mm	4.7 ± 1	1.7 ± 0.3

TABLE 3 Upper dental parameters by arch forms.

	Intercanine Width (means ± SD)	Intermolar Width (means ± SD)	Canine Depth (means ± SD)	Molar Depth (means ± SD)	Canine Ratio (means ± SD)	Molar Ratio (means ± SD)
Tapered	30 mm ± 2 mm	53 mm ± 2 mm	6 mm ± 1 mm	30 mm ± 2 mm	4.9 ± 0.9	1.7 ± 0.1
Ovoid	29 mm ± 5 mm	53 mm ± 8 mm	5 mm ± 1 mm	27 mm ± 4 mm	5.4 ± 0.8	1.9 ± 0.1
Square	32 mm ± 7 mm	55 mm ± 11 mm	5 mm ± 1 mm	29 mm ± 6 mm	6.4 ± 1.2	1.9 ± 0.3

TABLE 4 Lower parameters by arch forms.

significant difference was found between these two dental shapes (p: 1; p> 0.05).

With regard to upper dental arch, no sex differences were noticed (p> 0.05) as the males and the females exhibited similar percentage of the three arch shapes (Tapered, p: 0.47; OR: 0.75; CI: 0.35-1.63. Ovoid, p: 0.64; OR: 0.83; CI: 0.39-1.8. Square, p: 0.05; OR: 3.77; CI: 0.92-14.69).

Also as regards the lower arch form, no significant difference was found between boys and girls (Tapered, p: 0.88; OR: 0.94; CI: 0.43-2.04; Ovoid, p: 0.15; OR: 1.76; CI: 0.81-3.84; Square, p: 0.08; OR: 0.35; CI: 0.1-1.16).

Dental arch parameters

The dental cast measurements are reported in Table 2.

Statistically significant differences were recorded between males and females (p< 0.05). As regards the maxillary dental arch, males showed a higher intercanine widht (p: 0.0002), intermolar width (p< 0.001), canine depth (p: 0.04) and molar depth (p: 0.02) in comparison to the females. Instead, no significant difference was observed as regards canine ratio (p: 0.2) and molar ratio (p: 1).

Similar results were found also in the lower dental arch. In fact, boys exhibited a higher intercanine widht (p: 0.01; p< 0.05), intermolar width (p: 0.008; p< 0.01) and molar depth (p: 0.03; p< 0.05) in comparison to the girls. Instead, no significant difference (p> 0.05) was recorded as regards canine ratio (p: 0.61), molar ratio (p: 1) and canine depth (p: 0.08).

Dental parameters based on the arch form (maxillary arch)

The results (Table 3) indicate that intercanine width was very similar in the three groups: square form showed a slightly higher width in comparison to tapered form (p: 0.35) and ovoid shape (p: 0.11), however the difference was not significant (p> 0.05). Moreover, also the difference between ovoid and tapered forms was not significant (p: 0.06; p> 0.05).

Intermolar width was significantly lower (p< 0.01) in ovoid arches in comparison to tapered forms (p: 0.002), while no difference in comparison to square forms was found (p: 0.2; p> 0.05). Furthermore, no significant difference was observed between square and tapered forms (p:1; p> 0.05).

Canine depth was significantly higher (p< 0.05) in tapered arches in comparison to square arches (p: 0.043) and also in comparison to ovoid forms (p: 0.02). Instead, the difference between ovoid and square forms was not statistically significant (p: 0.14; p> 0.05).

Tapered arches showed a higher molar depth in comparison to ovoid (p: 0.001) and square casts (p: 0.04) while no significant difference was found between ovoid and square forms (p: 0.38; p> 0.05).

Square shapes exhibited a significanlty higher canine ratio in comparison to ovoid and tapered (p: 0.003 and p: 0.001 respectively), while ovoid and tapered forms were similar (p: 0.14; p> 0.05).

As regards molar ratio, very similar values were found in all three arch forms (p: 1 tapered/ovoid, p: 0.06 tapered/square, p: 0.06 ovoid/square).

Dental parameters based on the arch form (mandibular arch)

Results are summarised in Table 4. Intercanine width was similar in the three arch shapes and no significant difference was detected (square/tapered p: 0.09; square/ ovoid p: 0.1; tapered/ovoid p: 0.2).

Also intermolar width did not show any significant difference in the sample (p> 0.05; square/ovoid p: 0.5; square/tapered p: 0.2; ovoid/tapered p:1).

Canine depth was significantly higher in tapered forms in comparison to ovoid (p: 0.001) and square arches (p: 0.004). The difference between ovoid and square shapes was not significant (p:1; p> 0.05).

Molar depth was significantly higher (p< 0.01) in tapered forms in comparison to ovoid forms (p: 0.001); no significant difference (p> 0.05) was recorded between ovoid and square (p: 0.18) and between tapered and square arch (p: 0.35).

Square shape exhibited a higher canine ratio in comparison to ovoid and tapered forms (p: 0.001). The difference between ovoid and tapered arches was not significant (p: 0.14; p> 0.05)

No significant differences (p> 0.05) were observed in the arch forms as regards molar ratio (p: 0.06 ovoid/ square; p: 1 tapered/ovoid; p: 0.06 tapered/square).

Discussion

After the introduction of the Edgewise technique, archwire form has become the basis of orthodontic treatment planning, however little studies have been conducted on the rationale behind the precustomised archwire shape [Oda et al., 2010].

In a previous study, it was observed that most of prefabricated nickel-titanium archwires tend to be wider than the normal dental arch shape and these results have implications with respect to post-treatment stability and aesthetics [Braun et al., 1999]. Also, in a more recent research it was found that commercially available preformed nickel-titanium orthodontic wires exceeded both maxillary and mandibular intercanine and intermolar width with a subsequent increased orthodontic therapy duration need in order to restore the natural dental dimension [Bhowmik et al., 2012].

It was stated that the ovoid arches are the most choosen for orthodontic treatment [Celebi et al., 2016]; however tapered archwires are recommended for orthodontic subjects with narrow arch forms and gingival recession and after extraction of premolars in patients with crowding, while square arches are recommended for maintaining the width after upper maxillary expansion [Giuca et al., 2009; Kim et al., 2011].

As there are morphological differences between different races, ethnically matched prefabricated archwire should be selected, even with the modern multibrackets appliances.

The results of the present study showed that the Italian population had a similar tapered and ovoid tendency. Similar results were observed by Gafni et al. [2011] that found 45% of ovoid forms and 46.7% of tapered forms in white Angle Class I individuals.

Also, Kook et al. [2004] comparing dental arch shapes between North American white population and a Korean sample, observed that the dental square form was the rarest in the first, and the latter had a tendency to be larger and deeper than the white arches.

Nojima et al. [2001] compared the mandibular arch shapes of Japanese and Caucasian population and stated that in the Caucasian Angle Class I subjects, ovoid and tapered arch forms were almost equally distributed, accounting for more than 90% of the study population, while in Angle Class II dental arches the tapered form was the most frequent and in Angle Class III the three arch forms showed a similar distribution.

According to sex, significant alterations in linear measurements were found, but not in ratio parameters; all dental measurements were generally more pronounced in boys than in girls and these findings are in agreement with the results from previous studies [Slaj et al., 2011]. Instead, Camporesi et al. [2006] evaluated the mean configuration of the dental arches in a sample of Southern European subjects with and ideal natural occlusion using a three-dimensional analysis and did not find sexual dimorphism for either maxillary and mandibular arch shape.

In our study, in both males and females small variations in upper and lower intercanine width were recorded, while greater variations were found in the maxillary intermolar width, in the maxillary and mandibular canine and molar depth. Furthermore, small variations were seen in the upper and lower canine ratio while molar ratio did not show significant differences [Uysal et al., 2005].

In the present study, we chose to include only adolescents because most of the multibracket treatments are performed in this stage when all permanent teeth are erupted. It was seen in growth studies that intercanine and intermolar widths show minimal changes after age 14 [Sillman, 1964], therefore, we speculated that the dental arch dimensions of the sample included were almost fully developed.

The results of the present study are of clinical importance in orthodontics since an adequate knowledge of the form and dimension of the arches is helpful in planning the therapy of malocclusion [Giuca et al., 2015] and choosing the best archwires that maintain the patient's original arch form.

Nickel-titanium archwires have high springiness, but wire bending is poor because they do not exhibit plastic deformation. During the initial teeth alignment and leveling with fixed appliances, nickel-titanium archwire are generally used .012, .014, .016); these arches exert light orthodontic forces correcting rotations and crowding and they slighlty influence the dental arch shape, because they are often used for a short period of treatment. After initial alignment, large stainless steel wires or heavier rectangular nickel-titanium or heat-activated nickel-titanium are placed resulting in a higher dental arch form influence [Bhowmik et al., 2012]. Therefore, the clinician should select the appropriate preformed archwire form using the patient's dental cast and, for the stainless steel arches, adjusting intercanine and intermolar width.

In this study we evaluated only a white Italian population and different ethnic samples could also be studied and compared. Moreover, the measurements included in this analysis were limited and modern 3D intraoral scanners could be used [Kaihara et al., 2014]. Finally, further studies could be designed to compare dental arch form between Class I normal occlusion and Class II and Class III malocclusions.

Conclusion

The results of the present study show the maxillary and mandibular dental arch form parameters in an Italian adolescents sample with normocclusion.

A similar ovoid and tapered tendency was found, while the square form was the rarest.

According to sex, significant alterations in dental parameters were found, but not in ratio measurements. Males exhibit higher dental arch values in comparison to females.

Finally, small variations in upper and lower intercanine width and canine ratio were recorded, while higher variations were observed in the upper intermolar width, in the maxillary and mandibular canine and molar depth.

References

- Bhowmik SG, Hazare PV, Bhowmik H. Correlation of the arch forms of male and female subjects with those of preformed rectangular nickel-titanium archwires. Am J Orthod Dentofacial Orthop. 2012 Sep;142(3):364-73.
- Bourzgui F, Khribchi A, Rachdy Z, Housbane S, Othmani MB. Evaluation of arch forms depending on the angle classification. Int Orthod. 2016 Dec;14(4):528-36.
- Braun S, Hnat WP, Leschinsky R, Legan HL. An evaluation of the shape of some popular nickel titanium alloy preformed arch wires. Am J Orthod Dentofacial Orthop. 1999 Jul;116(1):1-12.
- Camporesi M, Franchi L, Baccetti T, Antonini A. Thin-plate spline analysis of arch form in a Southern European population with an ideal natural occlusion. Eur J Orthod. 2006 Apr;28(2):135-40.
- Celebi AA, Keklik H, Tan E, Ucar FI. Comparison of arch forms between Turkish and North American. Dental Press J Orthod. 2016 Mar-Apr;21(2):51-8.
- Collins BP, Harris EF. Arch form in American blacks and whites with malocclusions. J Tenn Dent Assoc. 1998 Jan;78(1):15-8.
- Ferro R, Besostri A, Olivieri A, Stellini E. Prevalence of occlusal traits and orthodontic treatment need in 14 year-old adolescents in Northeast Italy. Eur J Paediatr Dent. 2016 Mar;17(1):36-42.
- Fujita K, Takada K, QianRong G, Shibata T. Patterning of human dental arch wire blanks using a vector quantization algorithm. Angle Orthod. 2002 Aug;72(4):285-94.
- Gafni Y, Tzur-Gadassi L, Nojima K, McLaughlin RP, Abed Y, Redlich M. Comparison of arch forms between Israeli and North American white populations. Am J Orthod Dentofacial Orthop. 2011 Mar;139(3):339-44.
- Giuca MR, Pasini M, Galli V, Casani AP, Marchetti E, Marzo G. Correlations between transversal discrepancies of the upper maxilla and oral breathing. Eur J Paediatr Dent. 2009 Mar;10(1):23-8.
- Giuca MR, Pasini M, Caruso S, Tecco S, Necozione S, Gatto R. Index of orthodontic treatment need in obese adolescents. Int J Dent. 2015;2015:876931:1-7.
- Hajeer MY. Assessment of dental arches in patients with Class II division 1 and division 2 malocclusions using 3D digital models in a Syrian sample. Eur J Paediatr Dent. 2014 Jun;15(2):151-7.
- Housley JA, Nanda RS, Currier GF, McCune DE. Stability of transverse expansion in the mandibular arch. Am J Orthod Dentofacial Orthop. 2003 Sep;124(3):288-93.
- Kaihara Y, Katayama A, Ono K, Kurose M, Toma K, Amano H, Nikawa H, Kozai K. Comparative analyses of paediatric dental measurements using plaster and three-dimensional digital models. Eur J Paediatr Dent. 2014 Jun;15(2):137-42.
- Kim BI, Bayome M, Kim Y, Baek SH, Han SH, Kim SH, Kook YA. Comparison of overjet among 3 arch types in normal occlusion. Am J Orthod Dentofacial Orthop. 2011 Mar;139(3):e253-60.
- Kook YA, Nojima K, Moon HB, McLaughlin RP, Sinclair PM. Comparison of arch forms between Korean and North American white populations. Am J Orthod Dentofacial Orthop. 2004 Dec;126(6):680-6.
- Lombardo L, Fattori L, Molinari C, Mirabella D, Siciliani G. Dental and alveolar arch forms in a Caucasian population compared with commercially available archwires. Int Orthod. 2013 Dec;11(4):389-421.
- Lombardo L, Coppola P, Siciliani G. Comparison of dental and alveolar arch forms between different ethnic groups. Int Orthod. 2015 Dec;13(4):462-88.
- Nojima K, McLaughlin RP, Isshiki Y, Sinclair PM. A comparative study of Caucasian and Japanese mandibular clinical arch forms. Angle Orthod 2001;71:195-200.
- Oda S, Arai K, Nakahara R. Commercially available archwire forms compared with normal dental arch forms in a Japanese population. Am J Orthod Dentofacial Orthop. 2010 Apr;137(4):520-7.
- Sillman JH. Dimensional changes of the dental arches: longitudinal study from birth to 25 years. Am J Orthod 1964. 50:824–42.
- Slaj M, Spalj S, Jelusic D, Slaj M. Discriminant factor analysis of dental arch dimensions with 3-dimensional virtual models. Am J Orthod Dentofacial Orthop. 2011 Nov;140(5):680-7.
- Triviño T, Siqueira DF, Scanavini MA. A new concept of mandibular dental arch forms with normal occlusion. Am J Orthod Dentofacial Orthop. 2008 Jan;133(1):10.e15-22.
- Uysal T, Memili B, Usumez S, Sari Z. Dental and alveolar arch widths in normal occlusion, class II division 1 and class II division 2. Angle Orthod. 2005 Nov;75(6):941-7.