<Original Article>

Anterior and Posterior Overjet for Clinical Arch Coordination using 3-dimensional Analysis

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• Abstract

Introduction : The purposes of this study were to analyze the differences between the anterior and posterior overjets using bracket slot points, and compare two methods of overjet calculation according to different reference points using clinical bracket points on three-dimensional digital models.

Methods : A total of 35 normal occlusion models were scanned using a three-dimensional scanner (Orapix®, Orapix Co., Ltd, Seoul, Korea) and then, virtual brackets (0.022" Slot MBT preadjusted brackets, 3 M Co.CA. USA) were placed on the digital models using virtual setup program (3Txer® ver. 1.9.6, Orapix co., Ltd). Archwire-like curves were designed to analyze labial and buccal overjet.

Results : There were no statistically significance differences between the right and left overjet and between genders. The average overjet was found to be 1.67 $\pm$ 0.85mm at the central incisor area, 2.16 $\pm$ 0.88mm at the second premolar and 1.53 $\pm$ 0.71mm at the first molar.

Conclusion : It is recommended that overjet of individualized upper and lower arch to be 2.0mm at the anterior and posterior teeth.

• Keywords : Overjet, Arch form dimensions, Normal occlusion, 3-dimensional analysis

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INTRODUCTION

The identification of a suitable arch form for treating each malocclusion is a key aspect of achieving a stable, functional, and esthetic arch form. Failure to customize the arch form creates a possibility of relapse[1-4)]. Previous studies have suggested that relapse after treatment occurs due to complex reasons and long-term results are unpredictable[5,6)].

When intercanine and intermolar widths are not maintained, relapse to original malocclusion is more likely to occur. Maintenance of the original arch form should consider differences in arch form that exist in various ethnic groups. For example, Kook, et al[7] reported that the Korean arch form is different from the Caucasian arch form, and the square arch form is more frequent in Koreans than in Caucasians. Yun, et al[8] evaluated the morphological characteristic of the mandibular clinical arch form in a normal occlusion sample, but this study used two dimensions and calculated clinical bracket points without placement of brackets.

Coordination between the upper and lower arches is one of the most important aspects of achieving stable functional and esthetic results during orthodontic treatment. Because a transverse discrepancy could induce an adverse periodontal response, unstable dental camouflage, and functional and esthetic problems, maintenance of an adequate overjet during treatment is essential.

McLaughlin and Bennett[9] proposed that the lower archwire should be formed in the shape that would not alter the lower dental archform, while the upper arch archwire should be accurately coordinated with the lower one, and should be approximately 3mm wider than the lower archwire in all dimensions. However, this lacks accurate scientific data.

Most of the studies measured the arch form width and anterior overjet, but overlooked posterior overjet. These studies also used two-dimensional photocopies and indirect clinical bracket points calculated from the incisal edge and cusp tip or contact points, not the actual bracket bonding positions[10-14)]. A recent study has used three-dimensional images to evaluate the overjet[15)]. However, this study used the facial axis point to measure the archwire form which is not clinically oriented.

The purposes of this study were to analyze the clinical arch dimensions in Koreans with normal occlusion using clinical bracket points on three-dimensional digital models, analyze the differences between the anterior and posterior overjets using bracket slot points, and compare two methods of overjet calculation according to different reference points.

MATERIALS AND METHODS

All samples consisted of 35 maxillary and mandibular plaster models from 17 male and 18 female subjects ranging from 20 to 25 years of age with normal occlusion. The inclusion criteria were as follows:

(1) Angle's Class I molar and canine relationship
(2) Permanent dentition with normal tooth size and shape except the third molars
(3) 3mm or less crowding and 1mm or less spacing
(4) Absence of deviations of the dental midline
(5) 2mm or less curve of Spee
(6) No previous orthodontic treatment history
(7) No restorations extending to contact areas, cusp tips or incisal edges

The mandibular and maxillary casts were placed in the

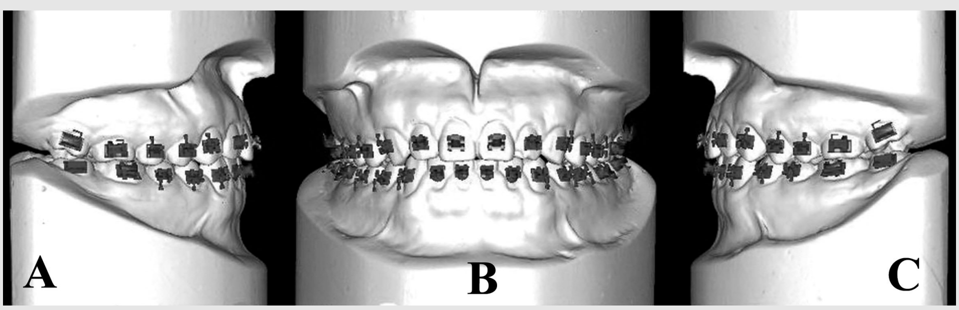

Figure 1. Virtual brackets and tubes on the scanned 3-dimensional digital model. A, right side; B, frontal view; C, left side.

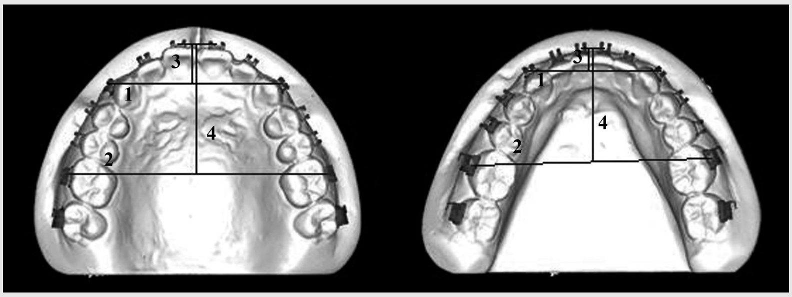

Figure 2. Dental arch width and depth. 1,intercanine width; 2,intermolar width; 3,canine depth; 4,molar depth.

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occluded relationship and scanned at 20 micrometer units' resolution with a three-dimensional scanner (Orapix®, Orapix Co., Ltd, Seoul, Korea).

All virtual brackets (0.022" Slot MBT preadjusted brackets, 3 M Co.CA. USA) were placed on the three-dimensional models using virtual setup program (3Txer® ver. 1.9.6, Orapix co., Ltd) by one operator.

Brackets were placed on all teeth from the right second molar to the left second molar (Fig. 1). Each bracket was placed at the facial axis (FA) point, which was defined as the midpoint on the facial axis of the clinical crown (FACC). It divides the most prominent point on the central lobe of the facial axis of all clinical crowns except for the molar teeth, where it is determined on the mesiobuccal groove[16].

The midpoint of the line connecting the bracket slot points of the mandibular right and left central incisors was used as the origin of the X, Y, and Z axes. The XY plane was formed from the origin point and the bracket slot points of the right and left first molars. The transverse direction was the X-axis, the antero-posterior direction was the Y-axis, and the line perpendicular to the XY plane was the Z-axis. The Z coordinates of the points of all teeth in the mandibular and maxillary arches were reduced to zero in order to obtain a planar projection of the dental arches.

Arch widths and depths were measured. The following 4 linear measurements were taken for each virtual model (Fig. 2):

1. Intercanine width: the distance between the canine bracket slot points
2. Intermolar width: the distance between the first molar bracket slot points
3. Canine depth: the shortest distance from a line connecting the canine bracket slot points to the origin between the central incisor bracket slot points
4. Molar depth: the shortest distance from a line connecting the first molar clinical bracket slot points to the origin between the central incisor bracket slot points.

Overjet measurements:

Two methods were used to measure the overjet (Fig. 3).

First method:

Projections of all the bracket slot points were made on a single plane. The distance between the upper and lower bracket slot points of each opposing tooth was taken to represent the overjet between them.

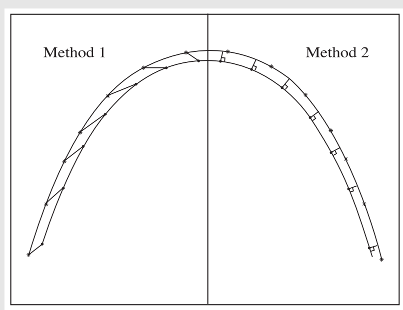

Figure 3. The two methods of overjet measurement. Left side, method 1; right side, method 2.

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Second method:

For measuring the overjet at each tooth a line was drawn from each mandibular bracket slot point perpendicular to the

Table I. Arch form dimensions in male and female

	Maxilla					Mandible				
	male		female		Significance	male		female		Significance
	mean	SD	mean	SD		mean	SD	mean	SD	
Inter-canine width	39.65	1.73	39.15	1.68	NS	30.88	1.70	30.21	1.41	NS
Inter1st premolar width	49.29	2.00	48.43	2.21	NS	41.73	2.53	40.88	1.68	NS
Inter 2nd premolar width	55.12	2.20	54.34	2.82	NS	48.35	2.47	46.98	1.74	NS
Inter 1st molar width	61.11	2.55	60.27	2.91	NS	55.67	2.49	55.22	2.21	NS
Inter 2nd molar width	67.26	2.65	66.14	3.38	NS	61.8	2.76	61.35	3.10	NS
Inter-canine depth	9.02	0.91	9.01	0.78	NS	5.05	0.90	5.17	0.93	NS
Inter 1st molar depth	32.10	1.39	31.76	1.70	NS	26.86	1.58	26.25	1.54	NS
Inter 2nd molar depth	42.50	1.85	41.81	1.79	NS	38.65	1.79	37.90	1.88	NS

Paired t-test. NS: not significant

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bracket base. This line was extended till it intersected with the projection of the upper archwire on mandibular bracket slot point's plane. The distance between the bracket slot point and the intersection point was taken to represent the overjet at this tooth.

Statistical analysis

ANOVA with Scheffe Post Hoc test for multiple comparison was performed to assess the differences in overjet among different areas of the dental arch in the 2 measuring methods separately. The tests were performed using SPSS 16.0 for windows (SPSS Inc. Chicago, Illinois). The measurement error was assessed by statistically analyzing the difference between duplicate measurements taken at least 2 weeks apart on 5 models selected at random. The measurement errors were generally small (less than 5% of the measured mean value) and within acceptable limits.

RESULTS

No significant difference was found between males and females for the arch dimensions either in maxillary or mandibular casts (Table I).

Labial and buccal overjet using method 1

The average labial and buccal overjet for both sides was 3.4 ± 0.78mm at the central incisor area, 4.74 ± 0.98mm at the canine, 4.73 ± 1.14mm at the first premolar, and 3.85 ± 0.91mm at the first molar. The lowest value was at the second molar and the highest value, at the canine. Overjet increased from the central incisor toward the canine, and decreased from the first premolar toward the second molar (Fig. 4). ANOVA showed that all differences were significant except between central incisor and second molar, between central incisor and first molar, among lateral incisor, second premolar and first molar, and among canine, first premolar and second premolar (Table II).

Labial and Buccal Overjet using method 2

The average labial and buccal overjet for both sides was 1.67 ± 0.85mm at the central incisor, 1.73 ± 0.97mm at the canine, 1.72 ± 0.83mm at the first premolar, 2.16 ± 0.88mm at the second premolar and 1.53 ± 0.71mm at the first molar. The lowest value was at the first molar and the

Table II. Comparison of overjet among different arch areas in the 2 measuring methods

	Method 1		Method 2	
	mean	SD	mean	SD
Central incisor area	3.40 [a, b]	0.78	1.67 [a, b]	0.85
Lateral incisor area	3.98 [c]	0.91	1.70 [a, b]	0.98
Canine area	4.74 [d]	0.98	1.73 [a, b]	0.97
First premolar area	4.73 [d]	1.14	1.72 [a, b]	0.83
Second premolar area	4.40 [c, d]	1.14	2.16 [a]	0.88
First molar area	3.85 [b, c]	0.91	1.53 [b]	0.71
Second molar area	3.17 [a]	0.92	1.87 [a, b]	0.84
P value	<0.001**		0.002*	

ANOVA. *, $P < 0.01$; **, $P < 0.001$
Means with the same letter are not significantly different among teeth areas according to Scheffe's grouping test.

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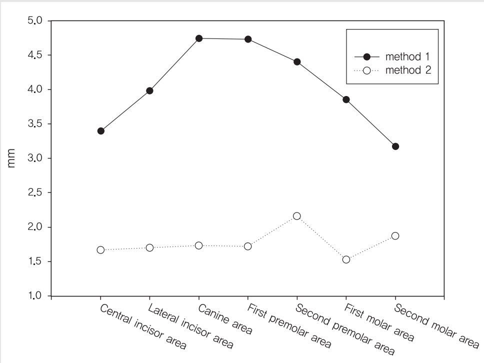

Figure 4. Comparison of overjet at each tooth from central incisor to second molar according to the 2 methods.

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highest value, at the second premolar. Overjet was almost the same from the central incisor till the first premolar, then increased about 0.4mm at the second premolar, then decreased about 0.6mm at the first molar then increased again about 0.3mm at the second molar (Fig. 4). ANOVA showed that all differences were not significant except the difference between second premolar and first molar (Table II).

DISCUSSION

As preformed superelastic wires have gained more popularity, the proper selection of the arch form type during treatment has become increasingly emphasized to achieve better post-treatment stability.

Recent articles have reported that a clinical bracket point derived from the contact point has been mathematically estimated from the most facial portion of the proximal contact area for each tooth and used as a landmark for mandibular arch form assessment[7,17,18]. This method seems to be of great clinical value in modern orthodontic techniques, in which preformed superelastic archwires are frequently used. Clinically, instead of one preformed archwire, it is more reasonable to have several types of preformed archwires available and to identify the patient's pretreatment arch form according to race and malocclusion.

Some studies used two-dimensional photocopies and indirect clinical bracket points calculated from the incisal edge and cusp tip or contact points[10-14]. Despite the biological significance of these anatomical landmarks, they do not provide clinical evidence of appropriate archwire forms. On the other hand, the use of FA points offers direct representation of clinical archwire shape.

Measurement with digital calipers on plaster models could produce accurate and reproducible results. However, Quimby, et al showed that measurements made from computer-based models appeared to be generally as accurate and reliable as manual measurements made from plaster models[20]. Zilberman, et al reported that the OrthoCAD measurement tool showed high accuracy and clinically acceptable reproducibility. Therefore the digital model is likely to become the day-to-day standard for orthodontic use due to its present advantages and future possibilities[21].

Costalos, et al reported that digital models have better inter-examiner reliability than conventional plaster models. The use of digital models produced by the OrthoCAD system seems to be a viable alternative to plaster models[22]. Moreover, measurement using the plaster models is limited to the anatomical landmarks only. However, a virtual setup program could allow placement of virtual brackets on the teeth and to measure these brackets. Hence, this procedure could be the biggest advantage of these programs.

Camporesi, et al reported that Brader arch form showed the least - but still statistically significant - differences in shape among the commercially available archwires[19]. However, using the bracket slot points gave much better representation of the clinical archwire shape.

In measuring the overjet between each opposing tooth, we used the horizontal distance between the bracket slot points of these teeth. Although this is not the shortest horizontal line between the upper and lower arch wires from each bracket slot point, it is a more clinical measurement than the mere geometrical shortest distance.

The amount of overjet increased from the central incisor toward the canine, and then decreased from the first premolar toward the second molar. This data suggests that simply adding 3mm to the dimensions of the entire lower arch is inaccurate for coordination of the upper and lower arches.

Kim[15] studied the labial and buccal overjet through the FA points. His study showed larger overjet values compared to our results, possibly due to the differences in the bracket base thickness both between the upper and lower brackets, and between the anterior and posterior brackets in our study. Another reason for the differences is that the best fit curve was not used in our study. This could explain the higher value of overjet at the second premolar and the second molar. Moreover, overjet can be affected by several factors like the inclination of teeth, and the shape and curvature of crowns.

The average labial and buccal overjet for both sides was 1.67 ± 0.85mm at the central incisor, 2.16 ± 0.88mm at the second premolar and 1.53 ± 0.71mm at the first molar. The lowest value was at the first molar and the highest value was at the second premolar. These differences were not significant except between the second premolar and the first molar. As such, the overjet can be considered homogenous as this statistically significant difference (0.7mm) is clinically unimportant.

Therefore, further research by typing the normal occlusion into tapered, ovoid and square arch form to evaluate the buccal overjet is required. Moreover, this study focused on the dental arch form in a normal occlusion sample, but consideration of the dimensions of the basal arch form may deserve some attention as cone beam computerized tomography is now readily available.

References

1. JM, Sinclair PM, Jones DL, Alexander RG. A computerized analysis of the shape and stability of mandibular arch form. Am J Orthod Dentofacial Orthop 1987;92:478-83.
2. De La Cruz AR, Sampson P, Little RM, Årtun J, Shapiro PA. Long-term change in arch form after orthodontic treatment and retention. Am J Orthod Dentofacial Orthop 1995;107:518-30.
3. McLaughlin RP, Bennett JC. Arch form considerations for stability and esthetics. Rev Esp Orthod 2000;29 Suppl 2:46-63.
4. Shapiro PA. Mandibular arch form and dimension. Am J Orthod 1974;66:58-70.
5. Little RM, Riedel RA, Artun J. An evaluation of changes in mandibular anterior alignment from 10 to 20 years postretention. Am J Orthod Dentofac Othop 1998;93:423-8.
6. Little RM, Wallen TR, Riedel RA. Stability and relapse of mandibular anterior alignment-first premolar extraction cases treated by traditional edgewise orthodontics. Am J Orthod 1981;80:349-65.
7. Kook YA, Nojima K, Moon HB, McLaughlin RP, Sinclair PM. Comparison of arch forms between Korean and North American white populations. Am J Orthod Dent Orthop 2004;126:680-6.
8. Yun YK, Kook YA, Kim SH, Mo SS, Cha KS, Kim JG, Tae KC. Mandibular clinical arch forms in Koreans with normal occlusions. Korean J orthod 2004; 36(6):481-7
9. McLauglin RP, Bennett JC. Finishing with the preadjusted orthodontic appliance. Semin Orthod 2003;9:165-83.
10. Ferrario VF, Sforza C, Miani A Jr, Taraglia G. Mathematical definition of the shape of dental arches in human permanent healthy dentitions. Eur J Orthod 1994;16:287-94.
11. Merz ML, Isaacson RJ, Germane N, Rubenstein LK. Tooth diameters and arch perimeters in a black and a white population. Am J Orthod Dentofacial Orthop 1991;100:53-8.
12. Nummikoski P, Prihoda T, Langlais RP, McDavid WD, Welander U, Tronje G. Dental and mandibular arch widths in three ethnic groups in Texas: a radiographic study. Oral Surg Oral Med Oral Pathol 1988;65:609-17.
13. Kim SC. A study on the configurations of Korean normal dental arches for preformed arch wire. Kor J Orthod 1984;14:93-100.
14. Lee YC, Park YC. A study on the dental arch by occlusogram in normal occlusion. Kor J Orthod 1987;17:279-86.
15. Kim KY. A study on Korean norm of labial and buccal overjet using three dimensional digital model. Master thesis, Catholic University of Korea, 2006.
16. Andrews LF. Straight wire-the concept and the appliance, LA: Wells, 1989, p32-33
17. 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.
18. Fujita K, Takada K, QianRong G. Shibata T. Patterning of human dental arch wire blanks using a vector quantization algorithm. Angle Orthod 2002;72:285-94.
19. Camporesi M, Franchi L, Baccetti T, Antonini A. Thin-plate analysis of arch form in a Southern European population with an ideal natural occlusion. Eur J Orthod 2006;28(2):135-40
20. Quimby ML, Vig KW, Rashid RG, Firestone AR. The accuracy and reliability of measurements made on computer-based digital models. Angle Orthod 2004;74:298-303.
21. Zilberman O, Huggare JV, Parikakis KA. Evaluation of the validity of tooth size and arch width measurements using conventional and three-dimensional virtual orthodontic models. Angle Orthod 2003;73:301-6.
22. Costalos PA, Sarraf K, Cangialosi TJ, Efstratiadis S. Evaluation of the accuracy of digital model analysis for the American Board of Orthodontics objective grading system for dental casts. Am J Orthod Dentofac Orthop 2005;128:624-9.