Evaluation of the curve of spee, curve of wilson and monson's sphere in Iranian adults

Mahdie Chavoshzadeh Natanzi [1], Maryam Azimi Zavaree [2], Mehran Torabi [3], Farnaz Taghavi Damghani [2], Seyed Mohammad Reza Hakimaneh [2], Sayed Shojaedin Shayegh [2], Farnoosh Taghavi Damghani [4*]

1. School of Dentistry, Shahed University, Tehran, Iran.

2. Department of Prosthodontics, School of Dentistry, Shahed University, Tehran, Iran.

3. Center of Excellence for Railway Engineering, Sciences and Technology University, Tehran, Iran.

4. Department of Prosthodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

ARTICLE INFO	ABSTRACT
Article Type: **Original Article** *Received:* 2 Feb. 2019 *Revised:* 20 Mar. 2019 *Accepted:* 15 Jun. 2019 ***Corresponding author:*** *Farnoosh Taghavi Damghani* *Department of Prosthodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.* *Tel:* +98-912-6207318 *Fax:* +98-21-84902473 *Email:* farnooshtaghavi@Sbmu.ac.ir	**Purpose:** One of the required information in rehabilitating the occlusal plane in dentistry is the radius of Monson's sphere, which like other anatomical indices varies in different races. The purpose of this study was to determine the radius of the Monson's sphere in a group of Iranian. **Materials and Methods:** 45 Iranian subjects (19 males & 26 females) aged from 18 to 25 were selected for this study. The x,y,z coordinates of cusp tips of all mandibular teeth except for the third molars obtained with a 3-dimensional digitizer, were used to derive a spherical model of the occlusal surfaces' curvature. From the best interpolating sphere, the radii of the Monson's sphere was computed. **Results:** Although all of the computed variables were greater in men, the occlusal curvature of mandibular arch was not influenced by gender. The mean radius of the Monson's sphere was 111.5mm (121mm in men and 104mm in women which was closer to the classic value of 4 inch, confirming Monson's observations). **Conclusion:** The average radius of the Monson's sphere in this study was greater than the classic 4 inch value proposed by Monson and this result may suggest racial differences in the normal dental arch form that is important in occlusal rehabilitation. Although more researches are necessary in future to improve treatment results. **Keywords**: Occlusal plane; Monson's sphere; Curve of spee; Curve of wilson; 3-dimensional digitizer; Iranian adults.

Introduction

Occlusal plane is a naturally occurring phenomenon in the human dentition [1]. Other parts of the masticatory system should be in harmony with this design and this is so important that even slight variations can result in occlusal instability and the patient would be dramatically less comfortable in function.

One important stage in oral rehabilitation is to determine the occlusal plane. Classically, the three dimensional arrangement of dentition produces occlusal curvatures that are in contact with the surface of Monson's sphere by it's radius measured as 4 inches [2,3,4,5]. Monson's Sphere is composed of 2 anteroposterior and mediolateral curves

named curve of Spee and Wilson respectively [2,5,6,7]. The curve of Spee contacts the tip of the lower canine , buccal cusp tips of the premolars and molars [2,6] and would ideally follow the arch through condyle and the curve of Wilson passes through the buccal and lingual cusp tips on both sides of the dental arch [2,5,7,8]. It is essential to reproduce curves of Spee and Wilson in the procedures of reconstructing the occlusal plane in prosthodontics and orthodontic treatments to permit disocclusion of the posterior teeth in eccentric movements [5,9]. Since these curvatures are correlated with the Monson's sphere radii [2,6,7], it is necessary to know the accurate value of this variable to precisely determine the occlusal curvatures [4,5,10]. Kagaya [8] and Nam [11] measured the median radii of the Monson's sphere in Japanese and Korean adults respectively and reported that this parameter was greater than the amount found by Monson. On the other hand, the study by Craddock et al. [5] showed that there is not a significant difference between the sphere radii of the adults and the 4-inch value of Monson's spherical theory.

The radius of the Monson's sphere like other anatomical indices can be variable in different races [12]. However, the validity of application of Monson's spherical theory in the Iranian population has not yet been verified. The purpose of this preliminary study was to determine the radii of the Monson's sphere and the mean depth of the curves of Spee and Wilson in a group of Iranian adults by three-dimensional analysis of dental casts.

Materials and Methods

Subjects:

26 women and 19 men aged from 18 to 25 (mean age 21.13 years old) participated in this cross-sectional study. All of them were students of Shahed Dental School that were selected based on the following criteria :1. Iranian, 2. complete permanent dentition except for the third molars. The exclusion criteria were history of orthodontic therapy, history of temporomandibular joint disorders, history of craniofacial trauma, severe periodontal disease and caries, cusp coverage dental restorations, unilateral or bilateral posterior cross bite, severe dental crowding and mandibular asymmetry (Appendix A) [4,8,13].

Written permission was obtained from all subjects and alginate impression was taken from the lower arc of them. Dental casts were reproduced from alginate impressions.

Digitization of arches:

The mandibular casts were fixed with a jig to the Mariana three dimensional digitizer (Mariana, Patent Number 45563, Tehran, Iran) [14]. Three dimensional (x,y,z) coordinates of mid-points of the incisal edges, canine cusps, buccal and lingual cusps of premolars , first and second molars, were then obtained using a dedicated computer program (Matlab 7.8.0.R 2009a, Monson's sphere).

Occlusal curve interpolation:

Arch orientation:

Orientation of the arches was done considering the standard intrinsic orientation (y-axis, antero-posterior; x-axis, medio-lateral; and z-axis, caudo-cranial): gravity center of each tooth (occlusal surface) was ad-measured by the buccal and lingual cusp coordinates of each posterior tooth and for the anterior teeth, the central points of incisal edges and canine cusp tips (the digitized point) were in accordance with this variable (Fig 1).
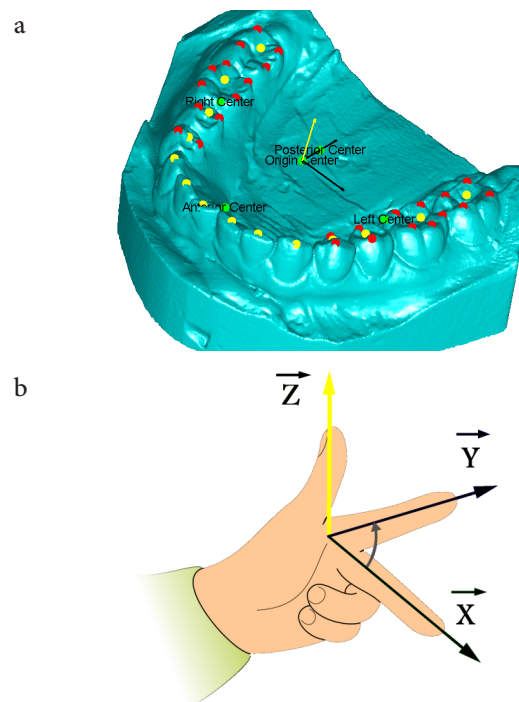

Figure 1. a- Mandibular dental arch and relevant Cartesian axes. Origin of axes: arch center of gravity; Y-axis passes through anterior and posterior arch centers of gravity; X-axis passes through the right and left centers of gravity. b- The black vectors are X-axis and Y-axis and the yellow vector is Z-axis extracted by means of the right-hand rule.

For each mandibular arch, gravity center of the cusp coordinates was applied to be considered as the origin of Cartesian axes. In all arches, centers of gravity of the anterior (central incisor to canine) and the posterior (premolars, first and second molars) teeth were also determined. The axis joining the two centers of gravity was set as the y axis of the dental arch that was placed in the y-z plane (symmetry plane). Left and right hemi-arch centers of gravity were then calculated separately, while the axis joining them was horizontal ;the parallel axis passing the origin of Cartesian axes was set as the x axis of the dental arch The z axis was oriented by means of the right–hand rule that was perpendicular to x-y plane.

Spherical model:

The radius of the sphere creating the three-dimensional configuration resulting from the occlusal surfaces and the coordinates of the center were calculated according to this steps: The x0 coordinate of the center of the sphere was set at zero (the center thus stayed on the y-z plane), while the y0 and z0 coordinates, and the sphere radius were estimated by progressive approximations that would minimize the SEE. SEE was computed by this procedure:

$$R=\sqrt{[(x-x0)^2 +(y-y0)^2 +(z-z0)^2]}$$

R= radius of the sphere

x0, y0, z0= sphere center coordinates

x0= 0

$$SEE=\sqrt{[\,\Sigma\,(\text{sphere center -cusp distance -R})^2\,/n]}$$

n= cusps number (ranging between 26 and 30)

An ideal approximation would result in the amount of zero for SEE which means the difference between all cusp tips to the center of the sphere is similar to the radius value. The computer program approximated with 0.5 mm steps in the following ranges: y, z between 15 and 200mm. The only constraint in the definition of the best interpolating sphere was that the center of the sphere had to stay on the y-z plane (plane of symmetry , x coordinate equal to zero) [4].

For each hemi-arch, a quasi-sagital plane was drawn from gravity centers of the canine and the second molar, having the inclination to the plane of symmetry. The best interpolating sphere then crossed with two quasi-sagital planes. Two circles were obtained to compute the radi of the left and right 'curves of Spee' [4,5] and the resultant average was defined as the radius of the curve of Spee.

The line perpendicular to the quasi-axial planes passing the cusp tips of the right and left canines and distobuccal cusps of the right and left second molars connecting this axial plane and the buccal cusp tips of other posterior teeth was estimated, and the point with maximum depth was considered as the depth of the curve of Spee on each side (Fig 2). The measurement of the depth of the curve of Spee was accomplished according to the mean amount of the right and left side results [15,16]. To produce the "curves of Wilson" , the similar approach was performed on the frontal plane in accordance with the right and left canines and the second molars (Fig 3).
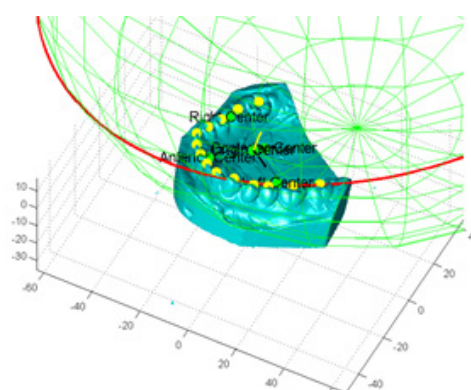

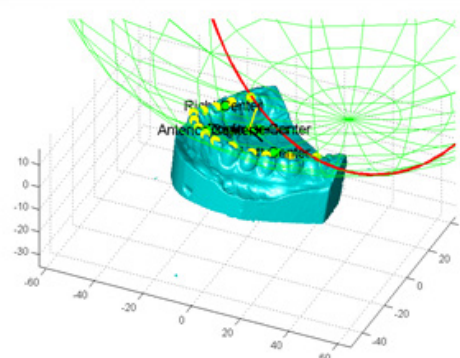*Fig 2.* The curve of Spee was obtained from the best interpolating Monson's sphere.

Fig 3. The curve of Wilson in molar area was obtained from the best interpolating Monson's sphere.

Reproducibility of Measurements

Several estimations were carried out for 10 arches (5 males, 5 females) that were selected by random in order to examine the reproducibility and reliability of these measurements, and the corresponding occlusal arches were intercalated. The x, y, z coordinate measurements of each reference point were used and the error was calculated for chosen models using the intraclass correlation coefficient (ICC), displaying acceptable

coefficient values (ICC = 0.86, $p<0.001$).

Statistical Analysis

To compare the measurements, the statistical analysis was done using SPSS 24 software. The differences in resultant calculations between males and females were compared with Independent Sample t-test. Paired Sample t- test was performed to collate the findings between the right and left sides. The significant level was set as 5% (P).

Results

The means and SDs of radi of the Monson's sphere, curve of Spee and curve of Wilson are shown in table 1. The mean radius of the Monson's sphere was about 111.5±41.716mm. It was 121.5±46.11mm in men and 104.4±37.5 mm in women ; there was no gender differences (P=0.23).

The mean radius of the curve of Spee was about 109.8±42mm, and the mean radius of the curve of Wilson was about 109.4±42.10mm in the canine area and 110.7±42.013mm in the molar area; in all casts, the canine's' curve of Wilson 'was smaller than the molar curve, with a difference of 1 mm. The three-dimensional occlusal curvature of the mandibular arch was not significantly influenced by gender (P>0.05), even if, on average, all of the variables obtained from the best-interpolating three-dimensional spheres were 17 mm greater in men than in women.

The mean depth of right and left curves of Spee are also shown in table 1 which was about 2.1±1.026 mm. There was no significant difference found based on gender (P=0.48) or the right/left side of the mouth (P=0.081). The radi of the Monson's sphere and the right/left curves of Spee was also computed in the subjects with canine-guidance (CG) and group-function (GF) eccentric pattern of occlusion (Table 2). The mean radi in subjects with GF occlusion was more than the CG ones, but it was not significant (P=0.6).

	Total (n=45)		Men (n=19)		Women (n=26)	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Radi (mm):						
Sphere	111.518	41.716	121.312	46.11	104.362	37.493
Right Spee	110.242	42.037	119.925	46.474	103.167	37.839
Left Spee	109.312	42.289	119.124	46.638	102.142	38.142
Spee	109.777	41.928	119.524	45.924	102.654	37.619
Wilson (canine)	109.382	42.106	119.239	45.5	102.179	37.891
Wilson (molar)	110.704	42.013	120.562	46.441	103.502	37.761
Depth (mm):						
Right Spee	897	881	87	027	916	778
Left Spee	331	122	213	109	415	147
Spee	114	026	042	069	002	166

Table 1. Three-dimensional spherical interpolation of mandibular arch occlusal curvature.

	CG*occlusion		GF**occlusion	
	Mean	*SD*	*Mean*	*SD*
Radi (mm):				
Sphere	*104.094 (n=23)*	*40.341*	*119.26 (n=28)*	*41.458*
Right Spee	*99.201 (n=21)*	*40.673*	*119.699 (n=24)*	*41.719*
Left Spee	*100.767 (n=19)*	*40.951*	*115.55 (n=26)*	*42.942*

Table 2. Radi of Sphere in subjects with canine guidance (CG*) and group function.

Discussion

In the present study the average radius of the Monson's sphere was calculated 111.5mm (4.39 inch), which is more than 4-inch radius advocated by Monson; this amount was close to the 4.35 inch (110.6mm) value in the Japanese people, reported by Kagaya et al [8]. In contrast with the results of this study, Kagaya found statistically significant differences in the sphere's radius between men and women (P=0.025). Ferrario et al reported the mean radius of sphere very similar to the classical 4-inch value in Caucasians which is in contrary with the results of this study [4]. Also Nam et al. in their study reported that in Korean the mean radius of the Monson's sphere was 110.89±25.75 mm which was significantly different between males and females [11].

The mean radius of the curve of Spee was 109.7 mm (men :119.5, women: 102.65, right side: 110.2, left side :109.3 mm). This was more than what was found in the study of Ferrario et al in Caucasians (men: 104.5, women: 99.7, the right and left sides: 102.1mm) and Xu et al in Japanese (mean: 83.4, men: 82, women: 85.1 mm) (4,15). The mean radius of the curve of Spee in women was greater than men in the study of Xu et al; this is in contrast with the result of the present study, but results found by Kagaya et al is more reliable than the latter study in the Japanese race; because of the number of its subjects and the three dimensional method applied.

The mean radius of the curve of Wilson was 110.7 mm in the molar area and 109.4mm in the canine area; which both of them were more than their correspondents in the Ferrario's study [4]. In both of these studies, the amount of curve in the molar area was 1-2 mm more than the canine area. The mean depth of the curve of Spee was 2.11mm (men: 2.04, women: 2.17, the right side: 1.9, the left side: 2.3mm); that was close to the Marshall's study in Northern European descent (mean: 2.02, men: 2.08, women: 1.96) [1] and more than Xu's findings in the Japanese (mean: 1.6, men:

1.9, women: 1.8) [15] and Cheon's study in Koreans (mean: 1.6, men: 1.61, women: 1.6) [16]. Unfortunately, Marshall and Cheon investigations are not completely comparable with this study; the reference plane in the present study was drawn from canine to the second molar, but in these studies the plan was drawn from central incisor to the second molar which resulted in a flatter curve and a shallower depth of curve of Spee. We found no statistically significant differences between the depth of the curve of Spee in the left and right sides of the arches. This is in contrast with the results of Farella et al study in Cacausians, who found the left-side curves were significantly deeper in both genders [13].

The radii of the Monson's sphere and the right/left curves of Spee in subjects with group function (GF) type of occlusion were more than subjects with canine guidance (CG) occlusion; but this difference was not significant. It was somehow predictable, because the curve in the GF occlusion is flatter than the CG occlusion. Monson described the optimum curvature of teeth by an sphere with a 4 inch radius in which occlusal arches are produced by the tangent of this sphere in the sagital and frontal planes [3]. The radi of the Monson's sphere, the curve of Spee, the curve of Wilson and the depth of the curve of Spee have been investigated in different races but there was no study in Iranian. Therefore the preliminary results of this study may be useful to design further studies to meticulously survey the Monson's sphere and occlusal curvatures in Iranian population.

Conclusions

1- Radii of the Monson's sphere and the mean depth of the curves of Spee and Wilson in a group of Iranian adults was determined by three-dimensional analysis of dental casts.

2- The radi of Monson's sphere in Iranian was greater than four-inch value suggested by Monson especially in men (p=0.23).

3- The depth of the curves of Spee and Wilson was not significantly influenced by gender (p>0.05).

4- There is no description of subjects' races in the Monson's article [7], but ethnic differences in the dental arch form between Japanese and American adults [12], and also in other races have been found [4,11,13,16]. The amount of the radius of the Monson's sphere in this study in a group of Iranian was shown to be different from the proposed value of 4 inch by Monson and it was closer to Japanese and Korean [8,11]. These findings can identify racial differences in the amount of this parameter. This is an important issue in prosthetic and orthodontic rehabilitations that requires further research with a larger sample size.

Conflict of Interest

There has been no conflict of interest in this study.

Acknowledgement

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