Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2017;6:2:134-142.

A Comparative Evaluation of Photographic and Radiographic Measurement of Facial Asymmetry: An In Vivo Study

Anshuj Ajay Rao Thetay[1*] Arpita Anshuj Thetay[2] Arpit Agarwal[3] Geetika Kataria[4]

[1]Reader, Department of Orthodontics & Dentofacial Orthopaedics, RKDF Dental College & Research Centre, Bhopal, India.
[2]Private Consultant, Bhopal, India.
[3]Post Graduate Student, Department of Orthodontics & Dentofacial Orthopaedics, RKDF Dental College & Research Centre, Bhopal, India.
[4]Post Graduate Student, Department of Orthodontics & Dentofacial Orthopaedics, RKDF Dental College & Research Centre, Bhopal, India.

ABSTRACT

Aim & Objectives: To evaluate the facial asymmetry with the help of patient's frontal photographs when compared with posteroanterior cephalograms in terms of area, perimeter and compactness by using visual studio 2005 software.

Materials and Methods: 20 patients of age18 -24 years having visible facial asymmetry were selected for the study. With the help of Barium powder, right and left medial and lateral canthus of eyes were marked before taking photograph and posteroanterior cephalogram. Photographs and posteroanterior radiographs were taken. The obtained photographs and radiographs were transferred to computer and were analyzed by Visual Basic Studio 2005 software. Obtained data was analyzed by Spearman rank correlation.

Result: It shows that there is no significant difference found in the mean values of the ratios for area, perimeter and compactness in photographs and radiographs hence photographs can be used as an effective diagnostic tool as good as radiographs to assess facial asymmetry.

Conclusion: This study shows that there is a close relationship between the ratio of area, perimeter and compactness of photograph and radiograph. These findings imply that photograph can be used as effectively as radiograph in diagnosing facial asymmetry.

Keywords: Photographic measurement, radiographic measurement, facial asymmetry.

INTRODUCTION

Symmetry[1, 2] may be defined as "equality or correspondence in the form of parts distributed around a centre or an axis, at the two extremes or poles or on the two opposite sides of the body". The majority of twin studies in orthodontics have relied on lateral cephalograms. Small number of landmarks has been used to describe facial hard tissue morphology. Linear distances have been used as an estimate of facial size and the angles between intersecting lines between landmarks as an estimate of facial shape[3].

Marmay Y. et al [4] (1979) suggested using the perpendicular bisector of the transverse distance between the foramina spinosum as a reliable cranial midline for submentovertex radiographs. Orthopantamogram (OPG) can be used to measure the asymmetry of the face but in both these techniques there is a problem of anatomic landmark identification because of bony superimposition.

Cheney E. A. [5] (1961) studied dentofacial asymmetries and their clinical significance. He found that there are four types of dentofacial

Received: Dec. 28, 2016: **Accepted:** Feb. 8, 2017
***Correspondence Dr. Anshuj Ajay Rao Thetay.**
Department of Orthodontics & Dentofacial Orthopaedics, RKDF Dental College & Research Centre, Bhopal, India.
Email: Not Disclosed

asymmetry which require special consideration. They are 1) unilateral anteroposterior displacements 2) vertical displacements 3) lateral displacements and 4) rotary displacements. Canted occlusal plane could be the result of a unilateral increase in the vertical length of the condyle and ramus. Similarly, the maxilla or temporal bone supporting the glenoid fossa could be at different levels on each side of the head.

Vig et al (1975)[6] conducted a study to determine the symmetry of the various parts of face by evaluating 63 posteroanterior cephalograms of "normal" children 9–18 years of age by using triangulation approach. This method can be used to study the relative asymmetry of the component areas of the facial complex by identification of bilateral structures and the midline on the radiograph, triangles are constructed that divide the face into various components. The right and left triangles are then compared for symmetry.

Masaomi K. et al (2003)[7] conducted a study on relationship between transverse dental anomalies and skeletal asymmetry by frontal cephalogram and 3 dimensional dental model analyses on 44 adult Japanese Class III patients. Analysis showed that transverse and vertical skeletal asymmetry variables were effective parameters for dental anomaly variables, and a significant high correlation between dental anomalies and skeletal asymmetry was found.

Hyeon- Shik Hwang et al (2006)[8] did maxillofacial 3- dimensional analysis for the diagnosis of facial asymmetry on 23 year old Korean man who had skeletal Class III malocclusion and a posterior cross bite on the left side. They concluded that both 3D and 2D images are useful to better understand asymmetrical structures.

Zhang X. et al (2007)[9] studied correlation between cephalometric and facial photographic measurements of 326 subjects. They concluded that both linear and angular measurements useful for characterizing facial morphology can be reliably measured from facial photographs.

Hence the purpose of the study is to evaluate the facial asymmetry on patient's frontal photographs and compare it with posteroanterior cephalograms as effective diagnostic tool in terms of area, perimeter and compactness by using Visual Studio 2005 software.

MATERIALS AND METHOD

Inclusion criteria:

- Adults in the age range of 18 -25 years with facial asymmetry on clinical examination.
- No history of trauma, bone disease, muscle dystrophy, congenital abnormalities, cyst, tumors or any other pathological conditions.
- Patient with no history of orthodontic treatment.

Exclusion criteria:

- Asymmetry due to any trauma, cysts, tumors, pathology, congenital anamoly or muscle dystrophy.
- Patient with history of orthodontic treatment.

20 patients were selected for the present study. Each patient was marked on right and left medial and lateral canthus of eyes with the help of Barium powder (Fig 1) before taking photograph and posteroanterior cephalogram so that common horizontal line can be drawn in both. All the individuals were asked to close in centric occlusion. Frontal view photographs and posteroanterior view radiographs were taken of all the 20 samples.

For standardization, photographs were taken using Nikon D70 SLR camera. Focal length of the lens was 135mm, distance from camera lens to patient was kept 160cms, shutter speed 500, aperture 11 with reflectors to avoid shadow. FH plane of the patient was kept parallel to the floor using custom made fluid level device (Fig 1).

Bizygomatic width of each patient was measured with spreading caliper so that the images can be transferred to the computer of original size. Posteroanterior radiographs were taken (Fig 2) taken using a digital cephalometric machine (Planmeca Proline XC, Finland) under standardized conditions i.e.

Frankfort horizontal plane of the patient was kept parallel to the floor by using custom made fluid level device. The film distance to X-ray tube was fixed at 160cms. Film was exposed at 68-70kv and 12 mA. The posteroanterior radiographs were then

Table 1: Master Chart Showing Photographic Values.

Patient Sr.no.	Area			Perimeter		Compactness	
		Right	Left	Right	Left	Right	Left
1	P	18.3	19	25.5	18.4	35.53278689	17.81895
2	P	19.5	20.3	26.4	19.9	35.74153846	19.50788
3	P	18.9	18.3	21.9	18.1	25.37619048	17.90219
4	P	20.4	21.4	23.2	27.1	26.38431373	34.31822
5	P	24.7	23.2	23.4	23.7	22.16842105	24.21078
6	P	19.5	21.3	24.6	19.9	31.03384615	18.59202
7	P	19.5	20.3	22.3	20.6	25.50205128	20.90443
8	P	18.5	19.3	19.2	17.9	19.92648649	16.60155
9	P	17.5	19.3	19.2	25.3	21.06514286	33.16528
10	P	19.5	20.2	23.6	21.1	28.56205128	22.0401
11	P	20.8	20.1	25.3	18.2	30.77355769	16.4796
12	P	24.3	21.9	22.3	22.8	20.46460905	23.73699
13	P	21.2	21.9	20.3	20.5	19.43820755	19.1895
14	P	23.6	21.3	21.6	20.2	19.76949153	19.15681
15	P	29.5	29.4	21.3	24.9	15.37932203	21.08878
16	P	22.4	21.4	22.7	21.4	23.00401786	21.4
17	P	19.9	19.6	20.6	18.5	21.32462312	17.46173
18	P	20.5	20.9	18.2	16.6	16.15804878	13.18469
19	P	22.3	21.5	18.9	17.2	16.01838565	13.76
20	P	18.6	18.7	19.3	15.2	20.02634409	12.35508

Table 2: Master Chart Showing Radiographic Values.

Patient Sr.no.	Area			Perimeter		Compactness	
		Right	Left	Right	Left	Right	Left
1	R	17.2	17.8	24.32	17.3	34.38735	16.81404
2	R	18.1	18.9	24.4	16.3	32.89282	14.05767
3	R	17.7	17.6	19.6	16.3	21.70395	15.09602
4	R	19	20.8	22.3	23.3	26.17316	26.10048
5	R	23	22.4	20.3	19.2	17.91696	16.45714
6	R	18.1	19.8	22.2	17.2	27.22873	14.94141
7	R	18.1	19	20.5	19.15	23.21823	19.30118
8	R	17.5	17.9	17.8	15.5	18.10514	13.42179
9	R	16.1	17.9	15.2	19.2	14.35031	20.59441
10	R	18.3	19	22.4	19	27.41858	19
11	R	19.3	18.7	22.6	17.6	26.46425	16.56471
12	R	23.1	20.5	20.5	20.2	18.19264	19.90439
13	R	20.1	20.9	18.4	18.05	16.84378	15.58864
14	R	22	20	18.36	18.1	15.32225	16.3805

15	R	28.3	28.2	18.2	22.6	11.70459	18.11206
16	R	21.2	20.3	17.1	20.2	13.79292	20.10049
17	R	18.7	18.4	18.3	15.2	17.90856	12.55652
18	R	19.4	19.7	16.2	14.2	13.52784	10.23553
19	R	21.1	20	16.7	15.2	13.21754	11.552
20	R	17.3	17.5	15.1	14.2	13.17977	11.52229

Table 3a: Spearman Rank Correlation Of Ratios Measured From Photographs And Pa Cephalograms. Descriptive Statistics.

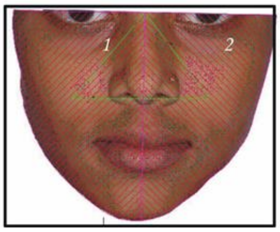
	Area	**Perimeter**	**Compactness**
Photograph			
Right side	20.9±2.8	21.9±2.3	23.6±6
Left side	20.9±2.34	20.3±3.1	20.1±5.6
Radiograph PA view			
Right side	19.6±2.8	19.5±2.8	20.1±6.8
Left side	19.7±2.3	17.9±2.5	16.4±3.8
Ratio			
Photograph	0.99±0.05	1.09 ± 0.17	1.23 ± 0.39
Radiograph	0.99±0.05	1.10 ± 0.18	1.26 ± 0.44

Table 3b: Correlation of Photograph with Radiograph PA view for ratios.

Statistics	***Area***	***Perimeter***	***Compactness***
ρ (rho)	**0.98**	**0.82**	**0.92**
p-value	**0.00(HS)**	**0.00(HS)**	**0.00(HS)**

Fig 1: Patient with barium marking on medial & lateral canthus of eyes with fluid level device.

Fig 2: Patient posteroanterior cephalogram with barium marking.



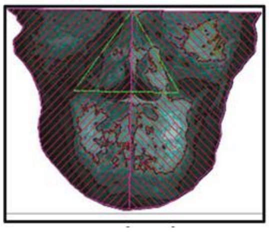


Fig 3a: Frontal photograph. Fig 3b: Posteroanterior Radiograph.

Fig 3A & 3B: Application of software for digitization of facial outline for measurement of area, perimeter and compactness in facial photograph and posteroanterior radiograph

scanned with Epson Perfection V- 700 Photo (Model J221A, Dual Lens System, Digital Ice Technology) negative scanner in 1:1 ratio.

The obtained photographs and radiographs were transferred to computer and were cropped by using Adobe Photoshop CS. The images were cropped in 6 x 4 inches and at a resolution of 300 pixel/inch. Then with Visual Basic Studio 2005 software, photographs and radiographs were converted in OLE (server). The obtained images were digitized by using AutoCAD software.

Following landmarks were marked:

Right and left inner canthus of eyes (Fig 3).

Outline of face was digitized upto the barium point on the lateral canthus of eyes by a series of mouse click in photographs and radiographs (Fig 3).

Midline is obtained by bisecting the base line (line passing through right and left inner canthus of eyes.) (Fig 3)

The right and left half were then compared on photographs and radiographs in terms of:

- **Area**: In photographs and radiograph the facial outline is marked as described previously up to the lateral canthus of eyes and from the midline right and left half of the face on the photographs and radiographs is measured with the help of autoCAD software[10].
- **Perimeter** : It is the length of facial outline which was digitized with a series of mouse click on both radiographs and photographs upto the barium point on the lateral canthus of eyes in photograph and radiograph and measured with the help of autoCAD software[10]
- **Compactness**: It is the combination of an area based and shape measurement which can be calculated by this formula on photograph and radiograph - Perimeter^2/Area. Compactness is important, since it is possible for the area of each segment to be similar, yet their shapes different[10].

Obtained data was analyzed by Spearman rank correlation.

RESULTS

Table 1 showing photographic values for area, perimeter and compactness.

Table 2 showing radiographic values for area, perimeter and compactness.

When mean value of area, perimeter and compactness of photographs and posteroanterior radiographs are compared in **Table 3-A** it shows that:

Mean value of the **area** for right side of the photograph was 20.9 ± 2.8 and left side was 20.9 ± 2.34 whereas mean value of the area of the right side for the radiograph was 19.6 ± 2.8 and left side was 19.7 ± 2.3.

Mean value of the **perimeter** for right side of the photograph was 21.9±2.3 and left side was 20.3±3.1 whereas mean value of the area of the right side for the radiograph was 19.5±2.8 and left side was 17.9±2.5.

Mean value of the **compactness** for right side of the photograph was 23.6 ± 6 and left side was 20.1 ± 5.6 whereas mean value of the compactness of the right side for the radiograph was 20.1 ± 6.8 and left side was 16.4 ± 3.8.

It shows that in both the methods viz. photographic and radiographic findings are suggestive of similar type of results i.e. the mean value of area, perimeter and compactness if increased in radiographs was also increased in photographs.

When mean value of ratios (Rt/Lt) of photographs and radiographs are compared in **Table 3-A** it shows that**:**

Mean value of the ratio of the **area** for the photograph was 0.99±0.05 and for the radiograph was 0.99±0.05.

Mean value of the ratio of the **perimeter** for the photograph was 1.09 ± 0.17 and for the radiograph was 1.10 ± 0.18.

Mean value of the ratio of the **compactness** for the photograph was 1.23 ± 0.39 and for radiograph was 1.26 ± 0.44.

It shows that there is no significant difference found in the mean values of the ratios for area, perimeter and compactness in photographs and radiographs hence photographs can be used as an effective diagnostic tool as good as radiographs to assess facial asymmetry.

The correlation between photographic and radiographic values for ratios of all parameters were assessed by using Spearman rank correlation coefficient test in **Table 3-B**

Spearman's rank correlation coefficient (ρ - rho) of the photograph with posteroanterior radiograph view for the area was 0.98 in which the p- value was 0.00 which is less than 0.05, shows highly significant correlation of area between photograph and radiograph.

Spearman's rank correlation coefficient (ρ - rho) of the photograph with posteroanterior radiograph view for the perimeter was 0.82 in which the p-value was 0.00 which is less than 0.05 shows highly significant correlation of perimeter between photograph and radiograph

Spearman's rank correlation coefficient (ρ - rho) of the photograph with posteroanterior radiograph view for the compactness was 0.92 in which the p-value was 0.00 which is less than 0.05 shows highly significant correlation of compactness between photograph and radiograph.

This shows that there is a close relationship between the ratio of area, perimeter and compactness of photograph and radiograph. Area, perimeter and compactness shows statistically significant relationship. These findings imply that photograph can be used as effectively as radiograph in diagnosing facial asymmetry.

DISCUSSION

Facial symmetry has long been recognised as an important determinant of the perception of facial attractiveness and plays an important in social interactions. The human face is bilaterally symmetrical, divided into right and left planes at the midline. Theoretically, both halves of this symmetric structure are mirror images of each other. However, there are some deviations from perfect symmetry.

A study was conducted by **Djordjevic et al (2013)**[11] on Three-dimensional analysis of facial shape and symmetry in 37 twin pairs. 19 monozygotic (MZ) and 18 dizygotic (DZ)] were laser scanned at the age of 15 during a follow-up of the Avon Longitudinal Study of Parents and Children (ALSPAC), South West of England twins. Analyses showed greater similarity of facial shape in MZ twins, with lower third being the least similar. Procrustes analysis did not reveal any significant difference in facial landmark configurations of MZ and DZ twins. The average faces of MZ and DZmales were coincident in the forehead, supraorbital and infraorbital ridges, the bridge of the nose and lower lip. In MZ and DZ females, the eyes, supraorbital and infraorbital ridges, philtrum and lower part of the cheeks were coincident. Zygosity did not seem to influence the amount of facial symmetry. Lower facial third was the most asymmetrical.

A study was conducted by **C. S. Huang et al (2013)**[12] on 60 healthy Chinese adults without any craniofacial deformity were recruited on a voluntary basis from a medical center, and included 30 men and 30 women, aged 20– 35 years, with a mean age of 27.7 ± 4.9 years (mean ± SD). The 3D facial images were captured with the GENEX 3D FACE CAM System (Genex Technologies, Inc. Kensington, MD, USA). The scan time for a face was 400 ms. The asymmetry index was calculated for each landmark. He found that the 3D facial asymmetry can be documented with asymmetry index. The landmarks located on the upper face had a smaller asymmetry index than the landmarks located on the lower face. The facial symmetry diagram can identify efficiently the location of asymmetry on a face.

A study was conducted by **Jelena Djordjevic et al (2014)**[13] on 270 subjects for to quantify facial symmetry in healthy adolescents and explore if there is any gender difference. Facial scans were processed and analysed using in-house developed subroutines for commercial software. The surface matching between the original face and its mirror image was measured for the whole face, upper, middle, and lower facial thirds. In addition, 3 angular and 14 linear parameters were measured. They found that Laser scanning is a non-invasive method for three-dimensional assessment of facial morphology and symmetry. The percentage of symmetry of the whole face was significantly lower in males (53.49 ± 10.73 per cent) than in females (58.50 ± 10.27 per cent; *P* < 0.01). There was no statistically significant difference in the amount of symmetry among facial thirds within each gender (P > 0.05). Average values of linear parameters were less than 1 mm and did not differ significantly between genders (P > 0.05). One angular parameter showed slight lip line asymmetry in both genders. Faces of male 15-year-old adolescents were less symmetric than those of females, but the difference in the amount of symmetry, albeit statistically significant, may not be clinically relevant. Upper, middle, and lower thirds of the face did not differ in the amount of three-dimensional symmetry. Angular and linear parameters of facial symmetry did not show any gender difference.

To evaluate the relationship between facial shape asymmetry and attractiveness in Mexican students **Arodi Farrera et al (2015)[14]** did a study in which 565 digital images of Mexican individuals (280 females and 285 males) of 18–68 age from different populations within the country. The photograph protocol consisted of a portable studio using a Pentax K1000 camera mounted in a tripod, with a 135 mm AF Pentax lens. The studio also included two flashes and reflective umbrellas, and a white background with the individual ID and a scale in centimeters. The distance between subject and the camera was held constant (2 m), taking care that the subjects' heads were on the Frankfurt horizontal plane. Finally, the resulting 35 mm films were digitized using ScanMaker 35 scanner. They found that found that every evaluated subject presents some degree of facial asymmetry, and that both fluctuating asymmetry and directional asymmetry were significant (P<0.0001) components of total facial asymmetry. Fluctuating asymmetry was slightly associated with age and there were no differences between geographical regions. Attractiveness was not correlated to levels of asymmetry in either sex.

For measuring facial asymmetry by a perception-based approach using 3D shape and color **Philipp Berssenbrugge et al (2015)[15]** did a study. They used Optical three-dimensional (3D) face scans of 30 healthy adults. Face-specific asymmetry indices were calculated by quantifying color differences as well as spatial distances between 3D data of a face and its mirrored copy. Subjective ratings of symmetry and attractiveness of the faces by 100 subjects are used to validate these indices. They found that the symmetry ratings show significant correlations with color and geometric asymmetry indices. The attractiveness ratings correlate only weakly with both indices. However, the product of the indices exhibits significant correlations with both attractiveness and symmetry ratings. The presented combined asymmetry index comprising shape and coloring turned out to reflect subjective perception of both facial symmetry and attractiveness. It thus promises to be a valid objective measure for facial esthetics

Edler R. et al (2003)[10] conducted a study to compare mandibular asymmetry with posteroanterior cephalometric and photographic measurements. 29 patient photographs and PA cephalograms were digitized for mandibular outlines. Four ratios were used to calculate mandibular asymmetry viz. area, perimeter, compactness and moment ratio. They found significant relationship for area, compactness and moment ratio for photograph and radiograph whereas perimeter showed non-significant relationship. In the present study total facial morphology was taken into consideration and it was found that -

A**rea ratio** (ρ – rho is 0.98 and p- value is 0.000 which is less than 0.05) showed highly significant correlation between photographs and radiographs which is comparable with Edler et al's study[10] (ρ – rho is 0.553 and p- value is 0.002).

Perimeter ratio (ρ – rho is 0.82 and p- value is 0.00 which is less than 0.05) showed highly significant correlation between photographs and radiographs whereas Elder et al's study[10] shows non-significant correlation (ρ – rho is 0.343 and p- value is 0.074)

Compactness ratio (ρ – rho is 0.92 and p- value is 0.00 which is less than 0.05) showed significant correlation between photographs and radiographs which is in accordance with Edler et al's study[10] (ρ – rho is 0.578 and p- value is 0.001).

Limitations:

The photographic set-up used in this study is time consuming and complicated that's why a intelligible and less time consuming method is needed. Greater precision is required during marking of perimeter so that there will be no or fewer chances for errors at the time of outline digitization. For patients who require orthognathic surgery for facial asymmetry treatment, photography alone cannot be used, other supplementary diagnostic methods are also required.

CONCLUSION

Area, perimeter & compactness ratio showed statistically significant correlation between the photographs and posteroanterior radiographs. The error in landmark identification is minimal or negligible. Photography is a noninvasive method as in this technique there is no radiation exposure. Soft tissue appearance is also taken into consideration which helps in diagnosis and treatment planning.

Within the limitation of the study it can be concluded that facial photographs can be used as a diagnostic tool as effectively as radiographs to assess facial asymmetry, to establish a proper orthodontic treatment plan and in long term monitoring of patients after orthodontic or orthognathic correction.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Samir E. Bishara, Paul S. Burkey, John G. Kharouf. Dental and facial asymmetries: A review. Angle Orthod 1994;64(2):89-98.

2. Stedman's Medical Dictionary, 24th ed. Baltimore: The Williams and Wilkins Company; 1982. p134.

3. Kohn LAP. The role of genetics in craniofacial morphology and growth. Annu Rev Anthropol 1991;20:261–78.

4. Marmay Y, Zilberman Y, Mirsky Y. Use of Foramina Spinosa to determine skull midlines. Angle Orthod 1979;49(4):263-268.

5. Cheney EA. Dentofacial asymmetries and their clinical significance. Am J Orthod 1961;47(11):814-829.

6. Vig PS, Hewitt AB. Asymmetry of the Human Facial Skeleton. Angle Orthod 1975; 45(2):125–129.

7. Masaomi Kusayama, Nobuyoshi Motohashi, Takayuki Kuroda. Relationship between transverse dental anomalies and skeletal asymmetry. Am J Orthod Dentofac Orthop 2003;123(3):329-337.

8. Hyeon- Shik Hwang, Chung Hyon Hwang, Ki-Heon Lee, Byung – Cheol Kang. Maxillofacial 3-dimensional analysis for the diagnosis of facial asymmetry. Am J Orthod Dentofacial Orthop 2006;130(6):779-785.

9. Zhang X, Hans MG, Graham G, Kirchner HL, Redline S. Correlation between cephalometric and facial photographic measurement of craniofacial form. Am J Orthod Dentofacial Orthop 2007; 131(1): 67-71

10. Raymond Edler, David Wertheim, Darrel Greenhill. Comparison of radiographic and photographic measurement of mandibular asymmetry. Am J Orthod Dentofac Orthop 2003;123(2):167-74.

11. J. Djordjevic, M. Jadallah, A. I. Zhurov, A. M. Toma, S. Richmond. Three-dimensional analysis of facial shape and symmetry in twins using laser surface scanning. Orthod Craniofac Res 2013;16:146–160

12. C. S. Huang, X. Q. Liu, Y. R. Chen. Facial asymmetry index in normal young adults. Orthod Craniofac Res 2013;16:97–104

13. Jelena Djordjevic, Arshed M. Toma, Alexei I. Zhurov Stephen Richmond. Three-dimensional quantifi cation of facial symmetry in

adolescents using laser surface scanning. European Journal of Orthodontics 36 (2014) 125–132

14. Arodi Farrera, Mar Iavillanueva, Mirsha Quinto-Sanchez, Rolando Gonzalez-Jose. The relationship between facial shape asymmetry and attractiveness in Mexican students. American journal of human biology 27:387–396 (2015).

15. Philipp Berssenbrugge, Maren Lingemann-Koch, Amalia Abeler, Christoph Runte, Susanne Jung, Johannes Kleinheinz, Cornelia Denz and Dieter Dirksen. Measuring facial symmetry: a perception-based approach using 3D shape and color. Biomed. Eng.-Biomed. Tech. 2015; 60(1): 39–47.