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Angular photogrammetric analysis of the soft tissue facial profile of Turkish adults

Sıddık Malkoç*, Abdullah Demir*, Tancan Uysal** and Naci Canbuldu*
Departments of Orthodonties, Faculties of Dentistry, *Selcuk University, Konya and **Erciyes University, Kayseri, Turkey

SUMMARY One of the most important components of orthodontic diagnosis and treatment planning is the evaluation of the patient's soft tissue profile. The aim of this study was to develop angular photogrammetric standards for Class I Anatolian Turkish males and females.

A random sample of 100 Turkish individuals (46 males and 54 females; ages 19–25 years) was obtained. The photographic set-up consisted of a tripod that held a 35 mm camera and a primary flash. The camera was used in its manual position and photographic records were taken of the subjects in natural head posture. The photographic records, 35 mm slide format, were digitized and analyzed using the Quick Ceph Image software program for Windows. Twelve measurements were digitally analyzed on each photograph. For statistical evaluation a Student's *t*-test was performed and the reliability of the method was analyzed. The results were compared with reported norms of facial aesthetics.

The nasofrontal (G–N–Prn), nasal (Cm–Sn/N–Prn), vertical nasal (N–Prn/TV), and nasal dorsum (N–Mn–Prn) angles showed statistically insignificant gender differences ($P > 0.05$). The nasolabial angle (Cm–Sn–Ls) demonstrated large variability. Gender differences were present in the mentolabial (Li–Sm–Pg) and cervicomental (G–Pg/C–Me) angles. The mentolabial angle showed a high method error and large variability. Facial (G–Sn–Pg) and total facial (G–Prn–Pg) convexity angles were similar, while Cm–Sn–Ls angle range was larger compared with other angles.

The mean values obtained from this sample can be used for comparison with records of subjects with the same characteristics and following the same photogrammetric technique. Angular photogrammetric profile analysis can provide the orthodontist with a way of determining problems associated with various soft tissue segments of the face.

Introduction

Treatment options in the early twentieth century were limited to extraction or non-extraction. Treatment goals were to establish a functional occlusion and stability of the dentition. While soft tissue aesthetics were considered, little could be done to alter the soft tissue profile (McLaughlin and Bennett, 1997). With the advent of orthopaedic and craniofacial surgical techniques in the 1960s and 1970s, facial harmony could be considered and 'even incorporated' as one of the treatment goals. Traditional diagnostic techniques use internal cephalometric landmarks, planes, and angles to arrive at a diagnosis and subsequent treatment plan (Roos, 2003).

One of the most important components of orthodontic diagnosis and treatment planning is the evaluation of the patient's soft tissue profile. Subtelny (1958), Burstone (1959, 1967), and Bowker and Meredith (1959) recommended that the analysis of the soft tissues should be taken into consideration for the correct evaluation of an underlying skeletal discrepancy because of individual differences in soft tissue thickness.

Numerous analyses have been developed to interpret the diagnostic information provided by lateral cephalograms (Merrifield, 1966; Ricketts, 1968; Burstone *et al.*, 1978; Lines *et al.*, 1978; Holdaway, 1983; Başçiftçi *et al.*, 2004) and most reports on dentofacial changes have been based on cephalometric data. However, in cephalograms, the soft tissue structures are recorded only in profile and limited to the anterior-most outline. Furthermore, patients are not accustomed to viewing and interpreting cephalograms or their tracings. Photographs, on the other hand, provide a more conventional documentation of the soft tissues of the face (Bishara *et al.*, 1995).

Different authors have included soft tissue parameters in photogrammetric and various soft tissue facial analyses based on standardized photogrammetric method have been described (Stoner, 1955; Neger, 1959; Epker, 1992; Arnett and Bergman, 1993a,b; Peck and Peck, 1995; Riveiro *et al.*, 2003). Other photographic methods to quantify facial aesthetics have also been used (Peerlings *et al.*, 1995).

There are differences in dentofacial relationships between ethnic and racial groups. Therefore, it is important to develop standards for various populations. Of the photogrammetric studies conducted on the Anatolian Turkish population, few have provided norms for Turkish adults. The aims of the present study were (1) to establish angular photogrammetric norms from standardized photographs of Anatolian Turks, (2) to identify possible gender differences between Anatolian

Turkish males and females, and (3) to compare Anatolian Turkish norms with the norms of other investigators who studied facial aesthetics.

Materials and methods

The subjects were dental students at the Faculty of Dentistry, Selcuk University. A random sample of 100 Turkish individuals (46 males and 54 females; ages 19–25 years) was obtained. A brief questionnaire was completed for all individuals that included name, age, origin, previous orthodontic treatment, and maxillo-mandibular relationship.

For the purposes of this study, the study sample met the following inclusion criteria. Turkish with Turkish grandparents, 19–25 years of age, Class I occlusion with minor or no crowding, normal growth and development, well-aligned maxillary and mandibular dental arches, all teeth present except third molars, good facial symmetry, determined clinically and radiographically, no significant medical history, no history of trauma, no previous orthodontic or prosthodontic treatment, and no maxillofacial or plastic surgery.

Photographic set-up

The method described by Riveiro *et al.* (2003) for the photographic set-up and record taking was used. The photographic set-up consisted of a tripod (Manfroto tripod, model FB 10 Series 075, 141 RC; Manfrotto Nord SRL, Villapaiera, Italy) that held a 35 mm camera (Canon, model EOS 5 35 mm; Shimomaruko, Tokyo, Japan) and a primary flash (Cullman primary flash, model BC 42; Cullmann Gmbh, Langenzenn, Germany). The tripod controlled the stability and the correct height of the camera according to the subject's body height. This ensured a correct horizontal position of the optical axis of the lens (Macro Canon lens 100 mm; Tokyo, Japan). A 100 mm focal lens was selected in order to maintain the natural proportions. The primary flash was attached to the tripod by a lateral arm, at a distance of 27 cm from the optical axis of the camera and 75 degrees from the upper right angle to avoid a 'red-eye effect' on the photographs. Another element of the set-up was a secondary flash (Starblitz secondary flash, model Sure-Hite 2600-GMS; Fuji Koeki Corporation, Tokyo, Japan), placed behind the subject. Its function was to illuminate the background and eliminate undesirable shadows from the contours of the facial profile. A slave cell allowed synchronization with the main flash.

Records

The camera was used in its manual position, the shutter speed was 1/125 per second, and the opening of the aperture f/11. The film (Agfachrome film CTX ISO 100; Germany) was developed using the E-6 process in the same laboratory so that the processing was identical throughout the study. The subject was positioned on a line marked on the floor, and framed alongside a vertical scale divided into 5 cm segments. From the scale hung a plumb line held by a thick black thread that indicated the true vertical (TV). The scale allowed measurements at life size (1:1). On the opposite side of the scale and outside of the frame a vertical mirror was positioned approximately 110 cm from the subject.

In order to take the records in the natural head posture (NHP; Riveiro *et al.*, 2003), the subjects were asked to walk a few steps, stand at rest facing the camera and near to the scale, look into their eyes in the mirror, and place their arms at their side. The lips should also be relaxed, adopting a normal position. Previously, glasses had been removed and the operator ensured that the patient's forehead, neck, and ears were clearly visible during the recording.

Digitalization

The photographic records, 35 mm slide format, were digitized and analyzed using the Quick Ceph Image (Quick Ceph Systems Inc., San Diego, California, USA) software program for the Windows operating system. The program was previously customized with the landmarks used in this investigation.

Analysis

The software calculated all measurements once they were identified on each landmark record (Figures 1–3), which had previously been digitized and scaled to life size. All the manual procedures were undertaken by the same operator (AD).

Statistical analysis

A Student's *t*-test was used to compare males and females. The reliability of the measurements was examined on the records of all 100 subjects, by repeating the point marking and digitizing procedures within a 4 week interval by the same examiner (AD). The reliability of the method was analyzed using the formula proposed by Dahlberg (1940). The results of the method error assessment are shown in Table 1.

Results

Descriptive statistics data including mean, maximum, minimum, and standard deviations for Turkish photogrammetric angular measurements together with the results of the Student's *t*-test comparing male and female measurements are shown in Table 2.

The nasofrontal (G–N–Prn), nasal (Cm–Sn/N–Prn), vertical nasal (N–Prn/TV), and nasal dorsum (N–Mn–Prn) angles showed statistically insignificant gender differences ($P > 0.05$). The relationship between the nasal base (columella) and the upper lip, analyzed by the nasolabial

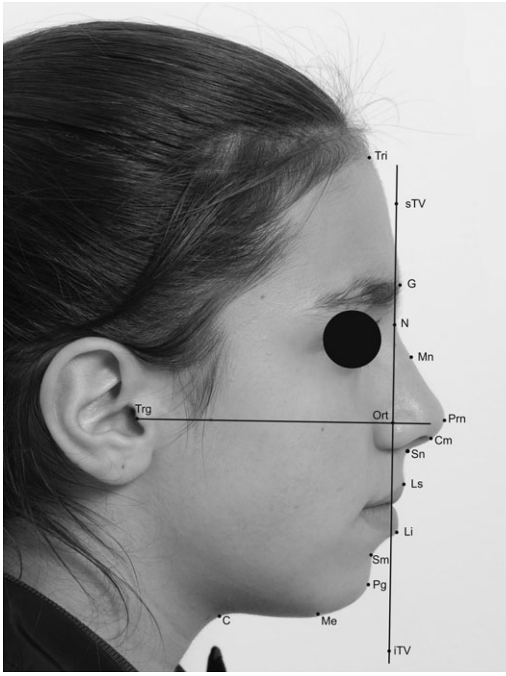

Figure 1 Landmarks and reference lines used in this investigation. G, glabella; N, nasion; Mn, mid nasal; Prn, pronasal; Cm, columella; Sn, subnasal; Ls, labial superior; Li, labial inferior; Sm, supramental; Pg, pogonion; Me, menton; C, cervical; Trg, tragus; sTV, superior point of true vertical; iTV, inferior point of true vertical; Ort point, junction of true vertical and true horizontal. Reference lines: sTV–iTV, true vertical; N–Ort (parallel to TV through nasion), true vertical in nasion; Trg–Ort (perpendicular to TV through Trg), true horizontal.

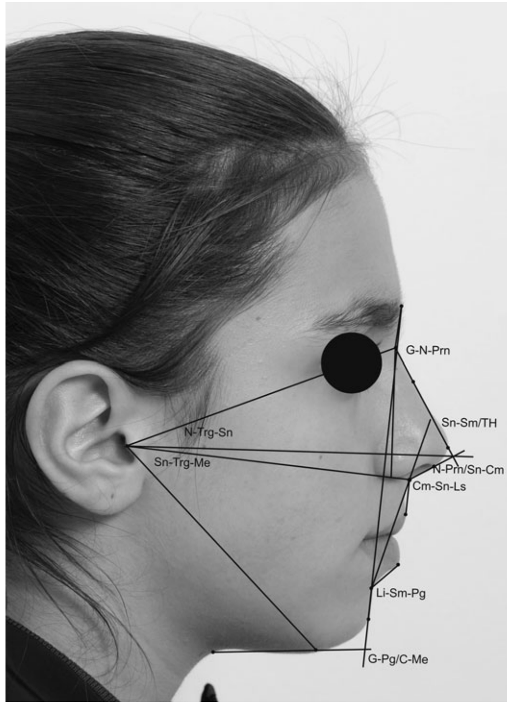

Figure 2 Angular measurements used in the analysis (clockwise): G–N–Prn, nasofrontal angle; N–Prn/N–Ort, vertical nasal angle; Cm–Sn–Ls, nasolabial angle; Li–Sm–Pg, mentolabial angle; Sn–Cm/N–Prn, nasal angle; N–Mn–Prn, angle of the nasal dorsum; G–Pg/C–Me, cervicomental angle; N–Trg–Sn, angle of the medium facial third; Sn–Trg–Me, angle of the inferior facial third; and Trg–Ort/Sn–Sm, angle of the head position.

angle (Cm–Sn–Ls), showed large variability from 75.40 to 126.90 degrees for males and from 81.71 to 129.90 degrees for females. The mentolabial angle (Li–Sm–Pg) was significantly wider in females than in males (males = 130.19 ± 8.50, females = 137.19 ± 10.93, $P < 0.05$). The cervicomental angle (C–Me/G–Pg) was significantly more acute in females than in males (males = 104.86 ± 9.86, female = 95.64 ± 7.74, $P < 0.001$). The inferior third was larger (male = 34.77 ± 2.61 degrees, female = 34.40 ± 2.80 degrees) than the middle third (male = 29.94 ± 2.39 degrees, female = 29.33 ± 2.58 degrees). The middle third (N–Trg–Sn) was narrower than the inferior third (Sn–Trg–Me), but both these angles showed no gender differences.

The lower profile orientation was analyzed by the line Sn–Sm and the true horizontal or angle of the head position (Sn–Sm/TH) but gender differences were not found. Facial (G–Sn–Pg) and total facial (G–Prn–Pg) convexity angles were similar. Overall, Li–Sm–Pg and G–Pg/C–Me angles showed gender differences and Cm–Sn–Ls angle range was larger compared with other angles (Table 2).

Discussion

It was the purpose of this investigation to obtain average parameters that define the soft tissue facial profile of the Turkish population. The nature of the soft tissue profile is affected by many factors, including ethnicity. As the profile varies according to malocclusion type, the present study used only Class I subjects. The inclusion criteria and methodology were orientated to identify normative values that can assist in diagnosis and treatment planning for Anatolian Turkish young adults seeking orthodontic treatment or orthognathic surgery. On the other hand, skeletal variations may exist in subjects with a Class I molar relationship. For example, Casko and Shepherd (1984) reported that cephalometric values for a sample of subjects with normal occlusions showed variation far beyond the mean values which are often used as treatment goals. For this reason, in the present study, the selected subjects were also judged to have well-balanced faces.

As it was intended to obtain a representative sample of normal Anatolian Turkish subjects, patients who had undergone orthodontic or facial surgical treatment were not included. Differences may exist between normal and aesthetically pleasing profiles, and difficulties in the application of supernormal cephalometric data have been related to racial differences (Pogrel, 1991). Thus, normal occlusion, which is not necessarily related to beauty, was the main criterion used to select the subjects (Peerlings *et al.*, 1995).

Current clinical interest in NHP derives from studies correlating NHP with craniofacial morphology, future

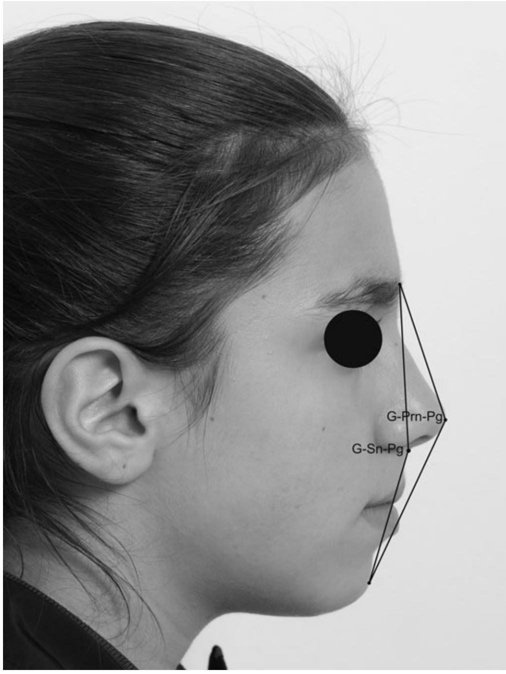

Figure 3 Angular parameters of facial convexity. G–Sn–Pg, angle of facial convexity; G–Prn–Pg, angle of total facial convexity.

Table 1 Method error according to the formula of Dahlberg (1940).

Parameters	Method error
G–N–Prn	1.50
Cm–Sn/N–Prn	1.45
N–Prn/TV	0.52
N–Mn–Prn	0.76
Cm–Sn–Ls	1.60
Li–Sm–Pg	2.16
C–Me/G–Pg	1.58
N–Trg–Sn	0.26
Sn–Trg–Me	0.18
Sn–Sm/TH	0.61
G–Sn–Pg	0.50
G–Prn–Pg	0.60

growth trends, and respiratory needs. It has also been argued that NHP is the logical reference and orientation position for craniofacial analysis and the publication of illustrations. Lateral cephalometric radiographs recorded routinely in NHP would be more meaningful for the clinician (Cooke and Wei, 1988). Individuals are presented as they appear in life when using NHP. Consequently, lateral profile photographs recorded routinely in NHP would be more clinically meaningful (Malkoç *et al.*, 2005b).

Although several anthropometrical investigations have been performed to identify acceptable facial profiles (Merrifield, 1966; Holdaway, 1983; Paul *et al.*, 1994, Ferrario *et al.*, 1998), these studies are not easily applied in clinical settings because of their requirements for expensive machinery and complex procedures. Furthermore, although the facial profile is a balanced and harmonized structure composed of several aesthetic subunits, these studies are limited to focal aspects of the facial profile (Park *et al.*, 2004).

In addition to direct anthropometry, several facial analysis systems and landmarks have been introduced (Neger, 1959; Epker, 1992; Arnett and Bergman, 1993a,b; Burger *et al.*, 1994; Peck and Peck, 1995; Auger and Turley, 1999; Riveiro *et al.*, 2003). However, most of these systems, except for those that are photographically based, require expensive equipment and complex procedures and provide data that are difficult to evaluate mathematically (Ferrario *et al.*, 1998). The ultimate compensator of facial contour relationships are the soft tissues, and most plastic surgeons concerned with total facial aesthetics work primarily from photographs or 'real' patients not roentgenograms (Park *et al.*, 2004).

There can be no argument about the overall reliability of cephalometric analysis. However, a desirable skeletal pattern does not imply desirable facial aesthetics, nor does an undesirable skeletal pattern imply undesirable facial aesthetics (Park *et al.*, 2004). On a daily basis, most orthodontists carry out soft tissue analysis mainly in a subconscious and unstructured manner. However, in the present study, soft tissue facial measurements were established by means of photogrammetric analysis in order to facilitate orthodontists to carry out more quantitative evaluation and make disciplined decisions.

Photogrammetric analysis offers some advantages in terms of human profile analysis. Firstly, with photogrammetric analysis, angular measurements are not affected by photographic enlargement as in cephalometric analysis (Malkoç *et al.*, 2005a). Thus, the technique can be used clinically for both pre-treatment planning and evaluation of a patient's post-operative results. Secondly, every profile fiducial point can be moved freely on a computer monitor using the cephalometric software program to determine the most appropriate profile points. Finally, angular photogrammetric profile analysis does not require expensive equipment and complex procedures, and it offers digitized results that are easily evaluated. Furthermore, the collected data can be arranged in unified charts.

The nasofrontal angle (G–N–Prn) demonstrates no significant gender difference. This finding is similar to that of Epker (1992), who found no gender differences in this angle in Caucasians on frontal and lateral facial views. The nasal (Sn–Cm/N–Prn), vertical nasal (N–Prn/TV), and nasal dorsum (N–Mn–Prn) angles also showed no significant difference with respect to gender. However, McNamara *et al.* (1992) found statistically significant gender differences for the nasal tip angle in a study of 141 adult Caucasians that satisfied the criteria of pleasing facial aesthetics and a Class I occlusal relationship. The method employed was based on

Table 2 Descriptive statistical data and comparison of male and female measurements.

	Male (*n* = 46)				Female (*n* = 54)				Student's *t*-test
	Mean	SD	Minimum	Maximum	Mean	SD	Min	Max	*P*
G–N–Prn	146.03	8.19	129.35	161.50	148.61	6.66	123.66	158.10	ns
Cm–Sn/N–Prn	76.21	6.72	60.40	90.25	78.41	9.17	59.58	110.34	ns
N–Prn/TV	26.57	3.16	21.42	32.81	26.21	4.07	19.00	33.83	ns
N–Mn–Prn	174.78	4.74	164.75	182.22	175.71	5.24	163.70	186.60	ns
Cm–Sn–Ls	101.09	10.19	75.40	126.90	102.94	10.43	81.71	129.90	**
Li–Sm–Pg	130.19	8.50	113.00	142.60	137.19	10.93	108.05	156.50	***
C–Me/G–Pg	104.86	9.86	86.79	123.93	95.64	7.74	79.86	119.56	ns
N–Trg–Sn	29.94	2.39	25.81	37.43	29.33	2.58	24.26	35.88	ns
Sn–Trg–Me	34.77	2.61	29.82	39.00	34.40	2.80	30.07	40.50	ns
Sn–Sm/TH	76.59	3.64	70.12	84.00	78.20	4.95	62.06	88.00	ns
G–Sn–Pg	170.60	6.15	161.00	188.00	168.78	5.44	157.41	179.77	ns
G–Prn–Pg	142.35	5.36	133.04	154.60	142.57	5.29	128.54	159.08	ns

**P < 0.01; ***P < 0.001; ns, not significant.

cephalograms. Lines *et al.* (1978) provided a mean range of 60–80 degrees for the angle of the intersection of the nasal dorsum and a tangent to columella. The present results are different from the findings of Riveiro *et al.* (2003) who reported considerable gender differences in these angles.

The relationship between the nasal base (columella) and the upper lip, analyzed by the nasolabial angle (Cm–Sn–Ls), is one of the facial profile parameters with greater clinical uncertainty. In the present sample, this angle showed large variations between males and females and thus should be interpreted with caution. Burstone (1967) reported a nasolabial angle of 74 ± 8 degrees (range 60–90 degrees) in a Caucasian adolescent sample with a normal facial appearance. Likewise, McNamara *et al.* (1992) reported a nasolabial angle of 102.2 ± 8 degrees for males and 102.4 ± 8 degrees for females in a study on lateral cephalograms of adult Caucasians with pleasing facial aesthetics. Yuen and Hiranaka (1989) reported an angle of 102.7 ± 11 degrees for males and 101.6 ± 11 degrees for females in a study of Asian adolescents on standardized photographic records. The mentolabial angle (Li–Sm–Pg) was significantly wider in females than in males. McNamara *et al.* (1992) also found similar results of 133–134 ± 10 degrees. The cervicomental angle (C–Me/G–Pg) was significantly more acute in females than in males. These results differ from those of Riveiro *et al.* (2003).

The lower profile orientation was analyzed by the line Sn–Sm and the true horizontal or the angle of head position but no gender differences were found. Likewise, Riveiro *et al.* (2003) reported 74.5 ± 5 degrees for males and 76.1 ± 5 degrees for females.

Arnett and Bergman (1993a,b) presented a clinical facial analysis based on previous studies and their surgical experience. For the facial examination, the G–Sn–Pg angle was used to assess the convexity/concavity of the profile. According to those authors, a Class I profile presented an angle range of 165–175 degrees, a Class II profile less than 165 degrees, and a Class III greater than 175 degrees. Yuen and Hiranaka (1989) reported for their Asian adolescent sample on photographic records, a G–Sn–Pg angle of 162 ± 5 degrees in females and 161 ± 6 degrees in males. The G–Prn–Pg angle was 142.35 ± 5.36 degrees in males and 142.57 ± 5.29 degrees in females. No sexual dimorphism was found. In the present investigation, the facial and total facial convexity angles were similar. G–Sn–Pg: 170.60 ± 6.15 degrees males and 168.78 ± 5.44 degrees females. Following the classification of Arnett and Bergman (1993a,b), the Class I profiles in the present sample were between 162 and 172 degrees.

Peck and Peck (1970) studied standardized cephalometric and photographic records of Caucasians with pleasing faces. They used the facial angle to assess the soft tissue facial profile. They analyzed vertical height by means of angles such as total vertical (N–T–Pg), nasal (N–T–Prn), maxillary (Prn–T–Ls), and mandibular (Ls–T–Pg) angles. In this investigation, the middle and inferior facial thirds were evaluated by the N–Trg–Sn and Sn–Trg–Me angles. The inferior third was larger than the middle third. Epker (1992) also reported that linear lower face height (Sn–Me) was larger (38 per cent) than the upper (G–Sn: 32 per cent) in relation to total face height in Caucasian subjects.

Conclusion

Orthodontists use dental, skeletal, and facial traits to diagnose and develop treatment plans for malocclusions. The traits most often used by orthodontists include the relative position of the upper lower lips, to a facial plane. These provide important information, but may offer only a limited insight into the facial changes that will result from treatment. The mean values obtained from the present sample can be used for comparison with records of subjects with the same characteristics and following the same photogrammetric technique. Angular photogrammetric profile analysis can provide orthodontists with a way of determining the problems associated with various soft tissue segments of the face.

Within the limitations of this study, the following conclusions were drawn:

1. There were gender differences in the mentolabial and the cervicomental angles.
2. The method error was high and there was large variability for the mentolabial angle. The results of this measurement should be assessed with caution.

Address for correspondence

Sıddık Malkoç
Selçuk Üniversitesi
Diş Hekimliği Fakültesi
Ortodonti Anabilim Dalı
42075 Kampüs
Konya
Turkey
E-mail: siddikmalkoc@yahoo.com

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