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Facial soft-tissue thicknesses in the adult male Zulu

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Abstract

The morphometric method of forensic facial reconstruction rests heavily on the use of facial soft tissue depth measurements. In reconstructing the Negroid face, much use has been made of the tables of soft tissue thicknesses of American Negroid cadavers. However, the genetic complexities of American blacks are well known. In addition it is felt that measurements made on the living are of more value than those made on the dead. In view of this it was decided to set up a table of norms for facial soft tissue depths of the living Zulu, an African Negroid who has remained relatively free from genetic admixture with other populations. The tightly controlled sample consisted of 55 healthy male Zulus, aged 20 to 35. Tissue depths at established landmarks were measured from lateral and oblique cephalometric radiographs. These were then combined with ultrasonic readings at other landmarks on the subject's face to yield a comprehensive set of tissue depth data. This paper presents a set of average facial soft tissue depth measurements from the Zulu face that results in the development of a new profile. It also provides a method for linking two systems of measurement.

Keywords: Forensics; Facial reconstruction; Soft-tissue thickness; Negroid; Cephalometrics; Identification

1. Introduction

Over the years, many approaches have been taken in attempts to make an

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identification from the skull [1,2]. One of these, three dimensional forensic facial reconstruction is the rebuilding of the soft tissues of the face, for an unknown skull, in an attempt to reproduce the likeness of its previous owner for the purposes of identification.

There are two basic methods [3] of modelling the face: a morphoscopic method using an 'anatomical approach' of reconstructing the musculature, fat and skin (as practiced by Gerasimov [4]); and a morphometric method which rests heavily on the use of average facial soft tissue depth measurements that have been gathered by various researchers [1,5–7] and which makes use of what could be called a 'column and beam' technique.

The methods employed for taking these measurements include tissue puncture using needles [8–12], lateral cephalometric radiographs [13–15], computed tomographic scanning [16–19], ultrasonics [20–23], and magnetic resonance imaging [24,25]. The reader is referred to Aulsebrook et al. [26,27] for in-depth bibliographies of these works (see also Krogman and İşcan [1]; İşcan and Helmer [2]; İşcan [28]). Valuable studies into the soft tissue depths for the main ethnic groups have been carried out. The most often quoted are Rhine and Moore [29] for Caucasoids; Suzuki [30] for Mongoloids and Rhine and Campbell [11] for Negroids.

As Cobb [31] pointed out, the American Negroid is a blend of three stocks: the African Negroid, the European White and the American Indian. He suggested that because of this variability one cannot describe a typical American black. Cobb thought that a survey of African blacks was needed to provide a comparative analysis of the rather complex black American facial anatomy.

If a system for predicting the likeness of an individual is to be effective it should be developed from genetically related people, and the characteristic pattern of that group isolated. With this data, the characteristic features of mixed population groups can be more effectively examined [32]. Satravaha and Schlegel [33] support this view when they emphasize that we should evaluate all available data to find standards that are 'valid for specific ethnic groups'.

Similarly, studying subjects taken from a wide range of ethnic background, ages and states of health, further compounds the difficulty of setting up basic norms for soft tissue depths. Studies of this type should restrict subject selection narrow parameters of age, ethnicity and health. It was also decided that instead of measuring the supine dead with their post-mortem distortion [34], measurements would be taken of upright living subject.

The aims of this study are to: (1) compile a set of soft tissue depth norms for Zulus, an African Negroid who has remained relatively free from genetic admixture with other groups and has not hitherto been measured for this purpose; and (2) develop a dual system of measurement incorporating the modalities of ultrasound and cephalometric radiography

2. Materials and methods

Ultrasound and cephalometric radiography have been shown to be accurate and

reliable methods of measurement [23,35–40] and they were chosen as the modalities for measuring the soft tissues of the face in this study.

It is well known by portrait artists that certain profiles of the face are simple and yet surprisingly descriptive of a person's likeness. The most effective of these are the lateral and three-quarter profile. The latter is so typical of a person that without it, a portrait painter could fail to render a good likeness [41–43]. Many a successful caricature has been created by the sole use of these two simple profiles (Fig. 1). It is therefore reasonable to think that measurements of soft tissue depths taken in these two planes would be of value in reconstructing a likeness.

Accordingly, cephalometric radiography was used to provide information on soft tissue depths as shown in two longitudinal planes of the head (midsagittal and three-quarter), whereas ultrasonic probing was employed to yield depth measurements for the intervening facial soft tissues.

The sample comprised 55 Zulu males, ranging in age from 20 to 35 years and in good health. They were selected from patients who attended the Oral and Dental Training Hospital, Durban, and who required radiographic examination for treatment. As far as could be ascertained all were representative of a racially and socially homogeneous population, drawn to Durban from all over Natal.

After obtaining informed consent, the subjects were weighed and measured for height. In the absence of average height-to-weight tables for Negroids, those compiled by the Metropolitan Life Insurance Company were consulted. The average individual rarely maintains a constant weight and it is therefore difficult to collect subjects with ideal height-to-weight ratios. A small variation in weight is generally dispersed throughout the body and does not necessarily reflect in the face. The factors constituting likeness are more dependent on proportions than on

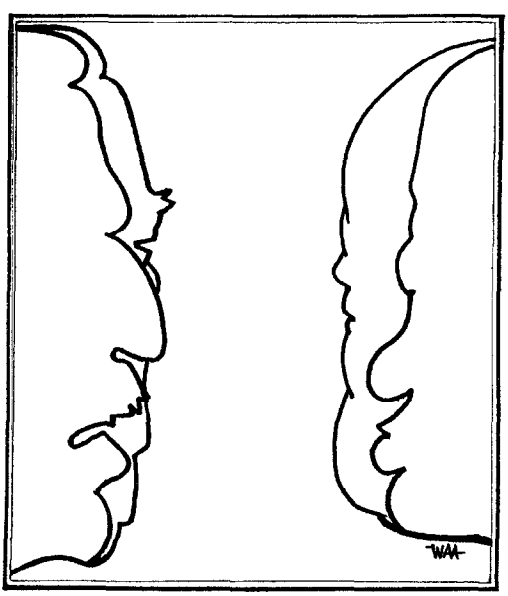

Fig. 1. The use of lateral and three-quarter profiles to draw simple caricatures.

finite measurements and so are not destroyed by a small variation in weight. The height of a person has little or no bearing on facial soft tissue thickness. Taking all this into account, only those people differing by less than 10 percent on either side of the stipulated average ratio were selected as subjects.

The subjects were then questioned, and blood tests were carried out to exclude those with anything that could affect the normal height-to-weight ratio, such as chronic infections, diabetes, or renal disease.

All subjects were given a physical examination. Those with fractures, swellings, malformations, distortions and asymmetries were excluded from the sample. Even the administration of a local anaesthetic can distort the tissue through swelling and flaccidity and so can render the case unsuitable for measurement. Other reasons for exclusion were those subjects having missing anterior teeth or those who were edentulous. These states produce an altered lip support and a disturbed vertical dimension, respectively. To preserve the natural drape of facial tissues all subjects were radiographed and scanned in the upright position.

2.1. Cephalometric radiography

In preparation for this study, a series of tests were conducted to determine: (1) the accuracy and dependability of the operator in measuring, (2) the accuracy and repeatability of the operator in locating landmarks, (3) the accuracy of the individual measuring systems, and (4) the matching of measurement accuracy within the dual system. In this study, both the dual system and the operator were found to be accurate and reliable.

Radiographs were taken using the Gendex GX-Ceph Counterbalanced Cephalometer System (Gendex Corporation, Milwaukee, Wisconsin, USA) and Agfa-Gevaert Curix R.P.I. film in cassettes with Hi-Plus intensifying screens. Before being placed in the cephalostat, a central vertical strip of the subject's face from the hairline to below the chin, about 1 cm wide, was carefully cleansed to remove greasy deposits. A thin line of barium sulphate paste 2 mm wide was then painted down the middle of the face to indicate the skin surface on the radiograph [44]. If this is not done the operator could incorrectly measure from what appears to be the skin surface but what is in reality the projection of the soft tissues on either side of the landmark. Examples of such midline errors occur between brow ridges and supraorbital soft tissues; the floor of the philtrum between the two philtral ridges; and in a chin cleft or dimple. The barium strip is not used in the oblique radiograph as the profile line is difficult to determine because the oblique profile is not a straight line.

In positioning the subject it is important that the facial features are not altered by postural strain or discomfort. The lower jaw should be relaxed. If it is not and the teeth are held in occlusion, a strained unnatural clenched look is imparted to the lower third of the face. Short lips forced to close when they are normally parted become pursed and produce an undesirable puckering of the chin. These distortions are foreign to a normally relaxed face and represent soft tissue in action rather than at rest.

Two radiographs were exposed, a standard lateral (as used in orthodontic analysis), and an oblique (at 45 degrees to the radiographic plane). It is important that the head be positioned at the same horizontal level in both views. In order to enhance and clearly delineate the soft tissue profile and to prevent 'burn out' of the anterior nasal spine in the lateral radiograph, an aluminum wedge was positioned in front of the collimator to attenuate the X-rays [44].

Landmarks were coded LR for lateral radiographs, and OR for oblique radiographs. They were named according to the bony landmark or a surface feature. Unless otherwise stated, soft tissue landmarks were established as follows: a tangent was drawn to the curve of the outer surface of the bone at the bony landmark. A line was then drawn perpendicular to the tangent at the hard landmark and extended outward to meet the face profile. The junction with the skin surface was registered as the equivalent soft tissue landmark. To avoid having to mention the method each time it is referred to below as 'by perpendicular.'

A point on 'the deepest curvature' or 'the maximum curvature' refers to a point on the maximum contour of that curve, whether it is concave or convex. The locus relates to the curve itself and is not selected in relation to an horizontal or vertical axis. Landmarks for the lateral cephalometric radiograph are shown in Fig. 2 and described in Table 1.

Unlike the lateral profile, the oblique profile is not a straight line as seen from

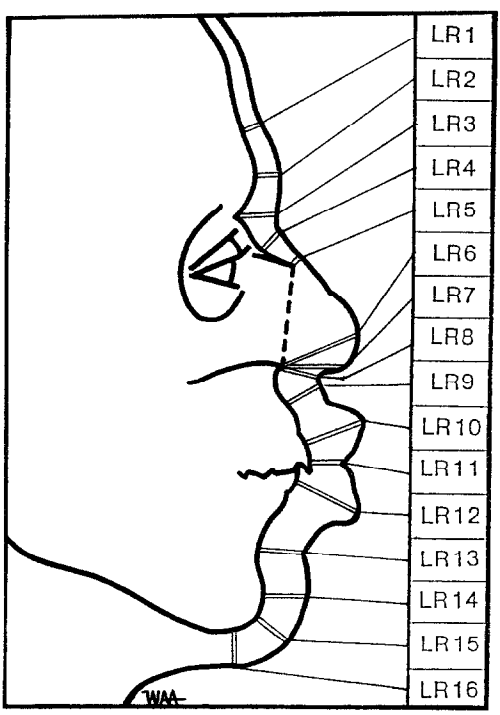

Fig. 2. Radiological landmarks on the lateral cephalogram.

Table 1
Landmarks on lateral cephalometric radiographs*

Code	Landmarks	Hard tissue description	Soft tissue description
LR1	Supra-glabella	On the outer surface of the frontal bone, at the deepest curvature of the dip (or if there is no dip, then midway) between the maximum curvatures of glabella and frontal eminence.	By perpendicular
LR2	Glabella	A point on the maximum anterior convexities of both hard and soft-tissue glabellas.	By perpendicular.
LR3	Nasion	The mid-point of the fronto-nasal suture.	On the surface of the skin in the midline on a line joining the upper limits of the two upper eyelid folds.
LR4	Mid-nasal	A point lying midway between nasion and rhinion.	By perpendicular.
LR5	Rhinion	The lowest point on the internasal suture.	By perpendicular.
LR6	Ant. nose tip	The acanthion.	A point on the most anterior curve of the nose, often called pronasale.
LR7	Inf. nose tip	The acanthion.	A point on the lowest curve of the nose tip.
LR8	Mid-columella base	The acanthion	The deepest point in the curvature lying at the base of the columella, often called subnasale.
LR9	Mid-philtrum	The landmark is the orthodontic point called Point-A or subspinale.	By perpendicular, or if that is not feasible a point lying midway between 'mid-columella base' (LR8) and 'mid-upper-lip margin' (LR10).
LR10	Mid-upper-lip margin	A point on the maximum labial curvature of the crown of what appears on the radiograph to be more anteriorly placed upper central incisor. If the surface is flat, then on the outer surface at the midpoint of the anatomical crown length.	On the maximum anterior curvature of the upper lip margin, often termed labrale superius.

LR11	Mid-lipline	A point on the maximum lower curvature of the incisal edge of what appears on the radiograph to be the more anterior of the two upper central incisors, or if the edge is worn down then midway between the anterior and posterior edges of the wear facet of that tooth.	The point at the red-line junction of upper and lower lips, often called stomion.
LR12	Mid-lower-lip margin	A point on the maximum labial curvature of the crown of what appears on the radiograph to be the more anteriorly placed lower central incisor. If the surface is flat, then on the outer surface at the midpoint of the anatomical crown length.	Tissue point is on the maximum curvature of the lower lip margin, often called labrale inferius.
LR13	Mid-labio-mental	Equivalent to Point-B or supramentale.	The deepest point in the labiomental crease.
LR14	Ant. symphyseal	A point is on the maximum forward curvature of the mental prominence, called pogonion.	By perpendicular.
LR15	Intermediate symphyseal	A point on the outer surface of the bone midway between anterior and inferior symphyseal points (see LR14 and LR16.	By perpendicular.
LR16	Inferior symphyseal	A point at the lowest point on the curve of the body chin at the menton.	By perpendicular.

*See Fig. 2 for location of landmarks.</

front view, but an undulating and broken line. In Fig. 3 it is seen as two discontinuous vertical shadow lines in both face and skull. The reason for this becomes clear in Fig. 4. In the Negroid face, what is seen as a continuous profile on the three-quarter view is in fact a combination of two separate profiles — one starting at the forehead and extending down to the bottom of the hard cheek; and the other arising at the side of the nose and running down to below the chin. There appears to be no bony support for the soft cheek. Its support in fact lies 'round the corner', so to speak: in the retro-molar region. In addition, in the Negroid, the bimaxillary protrusion often projects beyond the soft tissue cheek in the oblique radiographic view. Hard and soft radiographic landmarks must therefore be restricted to these two upper and lower oblique profiles. Landmarks for the oblique cephalometric radiograph are shown in Fig. 5 and described in Table 2.

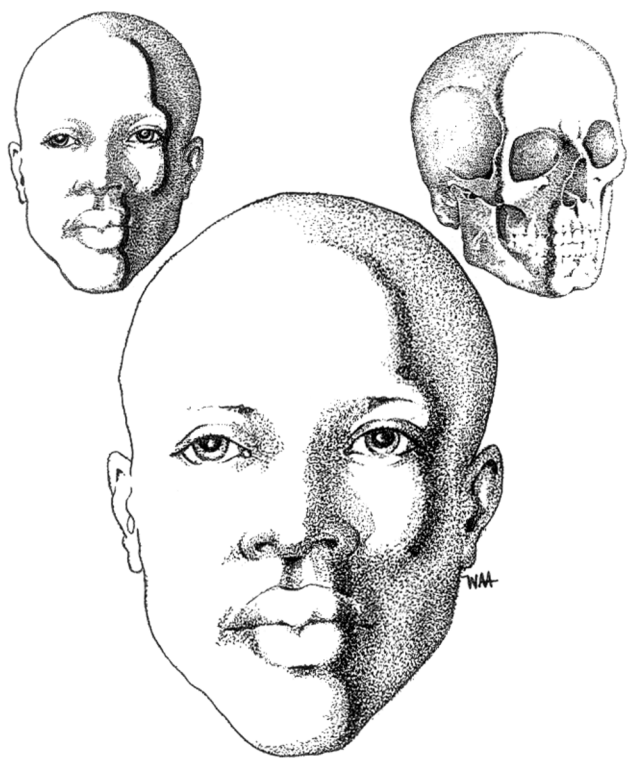

Fig. 3. Two shadow lines on the face and skull, indicating the curved 'edges' between front and side planes of the face.

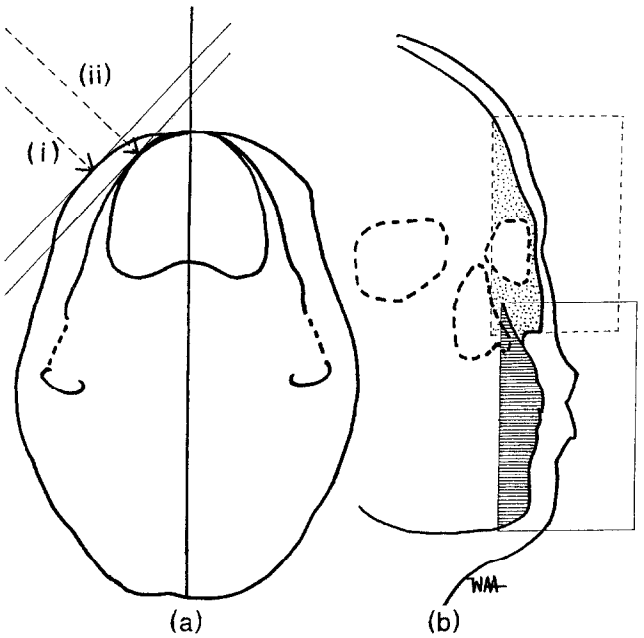

Fig. 4. Oblique profiles of the face: (a) the curves representing the forehead, maxilla and mandible are superimposed for comparison. This results in two separate 45 degree profiles of the face as seen in (b), namely, one for the forehead (stippled) and the other for the maxilla and mandible (hatched).

2.2. Ultrasound

The diagnostic ultrasound equipment used was the Ocuscan-400 Real-Time Ultrasound Contact Scanner with a coupled 10 MHz fixed short-focus transducer used in A-Mode (Cilco/Sonometrics, Huntingdon, West Virginia, USA.). The transducer or probe delivers an ultrasonic pulse that is generated from electrical energy by a piezo-electric synthetic crystal built into its head. The echoes are attenuated during their passage through the soft tissues by absorption, scatter and reflection. As the pulse reaches each level or interface between the various tissues a portion of the pulse is bounced back again towards its source and is recorded electronically as a measurable peak on a cathode ray tube or oscilloscope screen. The distance between blips or spikes is proportional to the distances between interfaces and is thus an indication of the thickness of tissues overlying the bone at that point.

The sites chosen as landmarks for ultrasonic probing should conform to a set of requirements. They should, (1) where possible, be similar to those used by other workers to ensure comparability, (2) be the same landmarks for all subjects, (3) be positioned over flat bone where possible, (4) be planned to lie at the summits of prominences like glabella, angle of jaw, or in depressions and folds such as the soft nasion or nasolabial fold (Fig. 6).

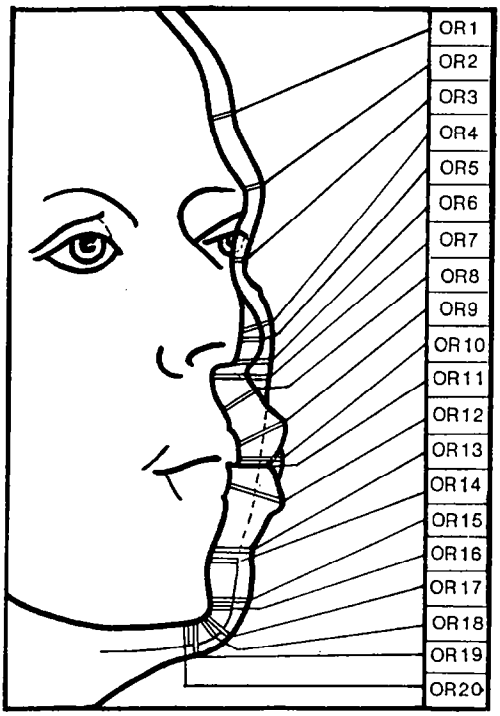

Fig. 5. Radiological landmarks on the oblique cephalogram.

The ultrasound landmarks were coded with the prefix US. Some landmarks were located by relating them to a surface feature of the face. Others could only be determined by first palpating the underlying bone and then marking the skin. All landmarks were named according to their surface location and shown in Fig. 7 and described in Table 3.

It is suggested that the probing of soft tissue depths should be done by an ultrasound expert to insure accuracy. The angulation of the probe is important. The central beam should be directed at right angles to the bone and the probe must maintain contact with skin without depressing it. Different pressure is applied at each measuring point. For example, the cheek is easily displaced inwards even though the skin itself may not be compacted and a very light pressure must be employed in this region. On the other hand, the soft tissue over the forehead is denser and can withstand firmer pressure before distorting. It is quite permissible to circumduct the probe whist maintaining the landmark as center, until an echo is picked up. However caution is advised not to wander off target in order to find a more 'suitable' point.

It is unwise to rely on a solitary reading. Only when a number of attempts indicate the bone/soft tissue interface peak to be in the same place on the monitor screen, should three further readings be taken of the depth. The highest of the three is recorded as being the depth taken under the least pressure.

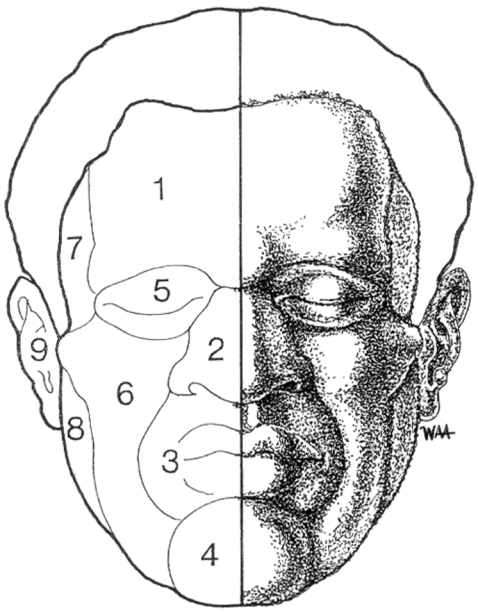

Fig. 6. Surface contours that determine landmark selection. Certain anatomic bulges and grooves are common to all faces. In front view, the features of the face can be clearly demarcated as: (1) forehead, (2) nose, (3) lips, (4) chin, (5) eyes, (6) cheek (upper hard cheek and lower soft cheek), (7) temple, (8) jaw, (9) ear.

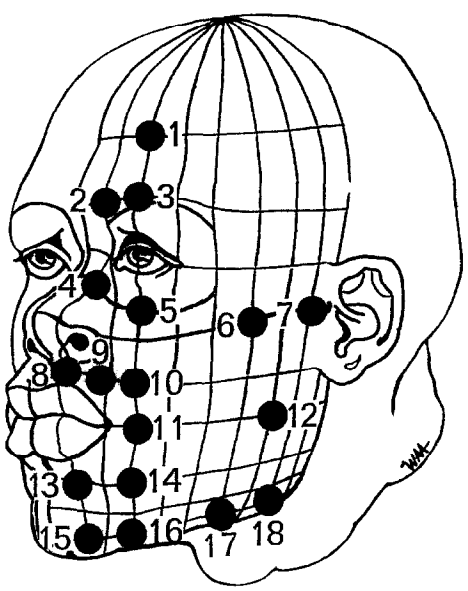

Fig. 7. Ultrasonic landmarks on the face. These are located on vertical meridia and horizontal parallels and should be viewed in relation to Fig. 6.

Table 2
Landmarks on oblique cephalometric radiographs

Code	Landmarks	Hard tissue description	Soft tissue description
OR1	Lateral frontal	A deepest point in the depression between the frontal eminence and the maximum curve of the supraorbital margin. If the bone is flat the point is on a horizontal level with the supra-glabella landmark (LR1) as seen on the lateral radiograph.	By perpendicular.
OR2	Lat. supra-orbital	A point on the maximum curvature of the supraorbital ridge.	By perpendicular.
OR3	Lateral orbital	A point at the deepest curvature (when it is present) of the lateral orbital margin, or else midway between OR2 and OR4.	By perpendicular.
OR4	Lat. zygomatic	A point on the maximum, most lateral curvature (as seen on the radiograph) of the zygomatic bone.	By perpendicular.
OR5	Lateral alare	This is not a measurement of tissue depth but of just how far the outline of the nose tip projects beyond the oblique profile. It is used as a guide to estimate the position of the side of the nose tip. A point located on the outermost maximum curvature of the zygomatic bone.	A point lying on the maximum curvature of the nasal soft tissue projection, whether that point be on the nose tip or the wing of the nose.
OR6	Inferior border of zygomatic	The lowest point on the inferior curvature of the zygomatic bone as seen on the oblique radiograph.	The equivalent point is on the skin surface and at the same level as the bony point.
OR7	Sub-zygomatic	A point at the deepest indentation between the zygomatic bone and maxilla as seen on the oblique radiograph.	Its outer point is on the surface of the cheek on a level with the bony point.
OR8	Sub-alare	A point on the outer curvature of the maxilla halfway between inner points of OR7 and OR9.	
OR9	Lat. upper lip margin.	A point on the maximum labial curvature of the crown of the upper canine.	A point on the maximum anterior curvature of the upper lip margin.
OR10	Angle of mouth	A point on the maximum curvature of the rounded incisal tip of the canine or if abraded the midpoint between outer and inner wear facet edges.	The maximum outer curvature of the modiolus.

OR11	Lateral lipline	As in OR10.	The red-line junction of upper and lower lips.
OR12	Lat. lower-lip margin	A point on the maximum labial curvature of the crown of the mandibular canine.	A point on the maximum anterior curvature of the lower lip margin
OR13	Lat. labio-mental	A point lying at the deepest curvature of the mandible as seen on the oblique radiograph (on about the same level as on the the bony Point B of LR13, seen on lateral radiographs).	The deepest point in the labio-mental crease as seen on the outer soft profile.
OR14	Lateral point B	The same as for OR13 (an apparent hard landmark.	On the outer soft profile, at the same level as the bony point.
OR15	Lateral mental	A point on the maximum lateral convexity of the mental protuberance as seen on the radiograph.	The landmark is at the same level, on the outer soft profile.
OR16	Lat. mandibular	The same as for point OR15.	On the outer soft profile at the same level as the bony point.
OR17	Intermediate mental	A point on the maximum convexity of the body of the mandible, halfway between the bony points OR15 and OR17.	By perpendicular.
OR18	Intermediate mandibular	The same as OR17.	By perpendicular.
OR19	Inf. mental	A point on the lower border of the mandible, on a vertical line running at right angles to a line that passes horizontally through OR15.	On the outer soft profile on the same vertical line as OR18.
OR20	Inf. mandibular	The same as for OR19.	Found vertically beneath this on the outer soft profile.

*See Fig. 5 for location of landmarks.

Table 3
Ultrasonic landmarks

Code	Landmarks	Description
US1	Frontal	A point on the forehead in a vertical line with the pupil of the eye and on the same horizontal level as radiographic points LR1 and OR1.
US2	Lateral glabella	A point on the soft tissue supraorbital ridge on a vertical line with the inner canthus of the eye.
US3	Supra-orbital	A point on the soft tissue supraorbital ridge in vertical alignment with the pupil of the eye.
US4	Lateral nasal	A point on the side of the bridge of the nose at the same horizontal level as LR4 and on a vertical line with the inner canthus of the eye.
US5	Infra-orbital	This point is located after palpation of the lower bony orbital margin. It is on the flat plane lying just below the lower rim of the eye socket and is in vertical alignment with the pupil of the eye.
US6	Mid-zygomatic	A point overlying the bony zygion, on the maximum horizontal and vertical outer curvature of the zygomatic arch.
US7	Root of zygoma	A point on the skin surface immediately above the mandibular condyle and superficial to the posterior root of the zygoma.
US8	Philtrum ridge	A point on the lateral ridge of the philtrum mid-way between the base of the columella and upper lip margin.
US9	Supra-labial	Over the maximum bulge of the canine eminence mid-way between the angle of the mouth and the root of the alar cartilage.
US10	Supra-commissural	A point on a horizontal level with US9 and on a vertical line with US11. It is positioned over the root of the first premolar.

US11	Commissural	A point on a horizontal level with the cheilion and immediately posterior to the commissural bulge It is frequently superficial to the crown of the first premolar.
US12	Mid-masseteric	A point on the skin surface lying over the center of an area bounded by the lower borders of the zygomatic arch and mandible, the anterior fibers of the masseter and the posterior border of the ascending ramus.
US13	Sub-labial	A point within the labiomental crease in vertical alignment with US9.
US14	Sub-commissural	A point in a vertical line with US10 lying on a horizontal level with US13.
US15	Mental tubercle, anterior	The most prominent point on the lateral bulge of the chin mound.
US16	Mental tubercle, lateral	A point posterior to US15 above, on the same horizontal level and in vertical alignment with US10 and US.14.
US17	Insertion of masseter, ant. (Antero-masseteric)	Determined by palpation, this point lies at the anterior edge of the insertion of the masseter muscle into the mandible.
US18	Insertion of masseter, post. (Postero-masseteric)	Similarly found, this point lies at the lower and posterior edge of the insertion of masseter into the mandible, just anterior to the gonion.

*See Fig. 7 for location of landmarks.

Table 4
Lateral radiographic soft tissue depth measurements (mm)

Code	Landmarks	Mean	S.D.	Min.	Max.
LR 1	Supraglabella	5.21	0.92	3.36	7.13
LR 2	Glabella	5.76	0.88	3.35	7.62
LR 3	Nasion	7.03	1.11	4.16	9.36
LR 4	Mid-nasal	4.82	1.04	2.96	6.96
LR 5	Rhinion	3.08	0.58	1.91	4.80
LR 6	Ant. nose tip	25.40	6.34	20.27	30.25
LR 7	Inf. nose tip	18.13	1.93	15.31	24.10
LR 8	Mid-col. base	12.80	2.44	9.66	24.01
LR 9	Mid-philtrum	12.10	1.63	8.12	16.99
LR 10	Mid-U lip marg.	14.61	2.17	10.43	21.05
LR 11	Mid-lipline	7.04	2.24	2.60	13.67
LR 12	Mid-L lip marg.	16.38	1.96	11.16	20.49
LR 13	Mid labio-ment.	12.87	1.65	9.09	15.95
LR 14	Ant. symphys.	11.66	1.79	7.18	15.79
LR 15	Intermed.symph.	9.19	2.61	5.58	17.42
LR 16	Inf. symphys.	7.26	1.98	4.44	15.58

*See Fig. 2 for location of landmarks.

Table 5
Oblique radiographic soft tissue depth measurements (mm)

Code	Landmarks	Mean	S.D.	Min.	Max.
OR1	Lateral frontal	5.37	1.01	3.41	8.00
OR2	Lateral supraorbital	6.18	0.98	4.15	8.46
OR3	Lateral orbital	3.71	0.76	2.40	6.41
OR4	Lateral zygomatic	7.97	1.77	4.44	13.25
OR5	Lateral alare	8.18	3.28	2.32	16.20
OR6	Inf.border of zyg.	13.22	2.53	7.27	20.00
OR7	Sub-zygomatic	18.74	3.07	8.33	26.72
OR8	Sub-alare	10.22	1.18	6.62	12.62
OR9	Lat. U. lip marg.	11.73	1.40	9.40	15.19
OR10	Angle of mouth	11.76	1.85	7.94	16.46
OR11	Lat. lip line	7.85	1.44	5.45	11.91
OR12	Lat. L. lip marg.	13.06	1.88	9.09	17.68
OR13	Lat. labiomental	12.08	1.59	8.43	15.73
OR14	Lat. point B	7.49	1.68	2.95	12.37
OR15	Lateral mental	10.42	1.63	7.27	15.18
OR16	Lateral mandibul.	5.43	0.85	3.95	8.56
OR17	Intermed. mental	8.65	1.67	5.23	12.16
OR18	Intermed. mandib.	4.40	0.88	2.73	6.82
OR19	Inferior mental	7.36	1.43	4.42	12.21
OR20	Inferior mandib.	3.95	1.19	2.23	10.43

*See Fig. 5 for location of landmarks.

Table 6
Ultrasonic soft tissue depth measurements (mm)

Code	Landmarks	Mean	S.D.	Min.	Max.
US1	Frontal	4.79	0.72	3.27	6.79
US2	Lateral glabellar	5.53	0.88	3.89	8.43
US3	Supra-orbital	6.05	0.87	4.48	8.49
US4	Lateral nasal	4.80	0.99	2.86	7.36
US5	Infra-orbital	6.56	1.88	3.45	12.42
US6	Mid-zygoma	7.02	1.05	4.99	11.26
US7	Root of zygoma	5.91	1.35	3.15	10.34
US8	Philtrum ridge	9.79	1.68	4.15	13.46
US9	Supra-labial	9.52	1.44	6.86	13.07
US10	Supra-commissu.	12.64	3.02	2.45	17.45
US11	Commissural	13.07	1.86	7.57	16.33
US12	Mid-masseteric	18.05	1.69	14.85	21.21
US13	Sub-labial	10.30	1.42	5.90	13.67
US14	Sub-commissural	11.54	1.66	8.05	15.29
US15	Mental tubercle ant.	8.99	1.87	5.33	13.41
US16	Mental tubercle lat.	8.61	1.50	5.44	12.72
US17	Insert. masstr ant.	9.47	2.16	4.72	14.23
US18	Insert. masstr post.	15.38	2.60	8.27	20.46

*See Fig. 7 for location of landmarks.

3. Results

From both the radiographic and ultrasonic measurement of facial soft tissue thicknesses of 55 subjects, a set of mean depth values was established for the 54 landmarks on the face. The mean soft tissue depths were measured to the second decimal place. This fine degree of measurement could be of use in other studies and has been retained during the statistical phases of this study. However, when it comes to the practical stages of reconstruction, the figures may be rounded to the nearest 0.5 mm because of the relative crudeness of manual control in modelling.

Table 4 shows the mean, standard deviation and minimum and maximum values of tissue depth from lateral radiographs. Both the highest and lowest tissue depths were recorded in the nose. The thickest readings were obtained from the nasal tip, the thinnest at rhinion (Fig. 2). Table 5 lists the same values for the oblique radiographic tissue depths. Maximum thickness are in the sub-zygomatic region and inferior border of the zygomatic region (Fig. 5). Least depth was found in lateral orbital region. Statistics for the ultrasonic measurements are given in Table 6. Tissue thickness is greatest in the mid-masseteric region and lowest in the frontal region (Fig. 7).

4. Discussion

The present study has produced a set of average facial soft tissue depth measurements for the healthy African Negroid male. It is a set of data taken from

living subjects. More landmarks were used than in previous studies of this kind and the focus has been shifted to the importance of the oblique profile in identification. Two recognized, reliable measuring modalities have been united into a single operational system for acquiring depth measurements in the human face. Moreover, these results may be used for interpopulational comparisons of facial tissue thicknesses.

For some time now, singular depth measurements have been used for forensic facial reconstruction, with varying degrees of success. This 'Depth System' has distinct limitations. The only thing one can be sure of is the depth of soft tissue at any one isolated landmark. It must also be remembered that they are *mean* measurements, often collected from a small range of loosely controlled subjects in regard to age, population and health. This type of facial reconstruction depends on tiny islands of clay, of average depth, to produce a large topological surface with a highly unique shape. The intervening modelling is applied 'by feel', ideally by professional researchers with years of study and sculptural expertise.

Further study into the continuous linear profiles of the face is in progress with the ultimate aim of producing predictably-shaped surfaces. In addition, a comparison with the African and American black facial soft tissue depths is also underway using data collected by Rhine and Campbell [11]. Once again, in basic studies of this nature, maximum effort should be made to keep the sample as genetically homogeneous as possible; and limit it to living subjects. After all, it is the appearance of the live person that remains in the memories of those who will be asked to view the facial reconstruction.

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