Use of dental dimensions estimated from personal portraits in human identification

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Abstract

Many cases of human identification in which traditional methods are not applicable challenge the experts' capability and versatility. In the absence of ante-mortem records, superimposition of skull images over photographs of a possible victim arises as a possible alternative. **Aim:** The present study was a pilot work willing to validate a new method of sizing images of the face by the use of proportionality principles, taking as reference a few predetermined accessories: a pair of sunglasses, a hat and a necklace. **Methods:** Twenty-one volunteers were photographed using each one of the accessories mentioned above. Pictures of the dental arches were also taken, with millimeter scale adjacent. The images with accessories were examined by a single operator, who estimated the mesiodistal width of the upper central incisor, for later comparison with the real measures. **Results:** The accuracy of the method was evaluated by the Student's t-test, which showed that the estimated measures were statistically greater than the real ones. **Conclusions:** The analysis of the data collected showed that the use of the accessories as a dimensional scale did not generate reliable results.

Keywords: forensic dentistry, victims' identification, tooth.

Introduction

Forensic dentistry is an important science for human identification, especially when conventional methods cannot be applied, usually due to advanced decomposition, carbonization or fragmentation of the body. In such cases, and in the absence of *antemortem* dental data to be compared, craniofacial image superimposition can be an accurate and reliable technique for human identification[1-3]. However, before superimposing images of the skull over photographs of a possible victim, it is mandatory that they both are properly sized in the same scale[4-5].

Authors that apply computer-assisted craniofacial superimposition size reach the scale through craniometric and cephalometric landmarks easily identifiable in the face and the skull[6-7], even thought this assessment is influenced by the thickness of local soft tissue - amount and disposition of fat - which can vary among different populations[8].

Considering that the teeth are naturally visible throughout life, not being influenced by soft tissue, and commonly shown in smiling pictures, they are reliable size reference for comparing images of skull and personal pictures[9]. Although

technical advances allow the three-dimensional facial reconstruction[10-12], this is not an identification method, but rather a form to disseminate a facial approximation of that subject, willing to achieve someone who knew him/her, and can provide reliable *antemortem* records for human identification.

Human identification through craniofacial image superimposition has been tested and used by different researchers and experts. However, the proper scaling of the photographs to be compared is a precondition for an accurate evaluation. The aim of this pilot study was to test the feasibility of obtaining real size of teeth from personal photographs, using common accessories as size reference, in order to use them for the proper scaling required for image superimposition.

Material and methods

Sampling

Pictures of 21 volunteers (8 males and 13 females) were taken by a single photographer. All the subjects were aged between 21 and 60 years, and agreed to participate of the study by signing an appropriate document. Subjects with absence or anomalies in the upper central incisors were excluded, as well as those with notorious systemic pathology.

Methods

From each participant the following photographs were taken:
• dental arch, in frontal view, with lip spacer, and scale number 2 from American Board of Forensic Dentistry placed at the same visual plane of the upper central incisors;
• bust photograph, wearing a pair of sun glasses, and smiling;
• bust photograph, wearing a cap, and smiling;
• bust photograph wearing a round pendant necklace, and smiling – only the female subjects.

The images obtained were stored in a computer managed by Windows Vista™, and analyzed by the software Adobe Photoshop™. From the bust photographs, the mesiodistal dimensions of the upper central incisors were measured, which were called TMP (tooth measure at the picture). From the same picture, using the same zoom, the size of the adornment (sunglass, a rounded detail of the cap, or necklace) were measured, to obtain what were called AMP (adornment measure at the picture), as shown in Figure 1, with the cap. Figure 2 shows the sunglasses and the necklace. All the measurements were stored in an Excel™ file.

Then, the life-size of the adornments worn by the subjects were taken, with a digital caliper (Digimess, São Paulo, Brazil), which was called adornment's real measure (ARM). From the measures taken, tooth's real measure (TRM) was estimated, according to algebra fundamental rules of proportion, translated by the following equation:

Fig. 1 - Example of the measurements taken from the bust photographs: tooth measure at the picture (TMP), and adornment measure at the picture (AMP).
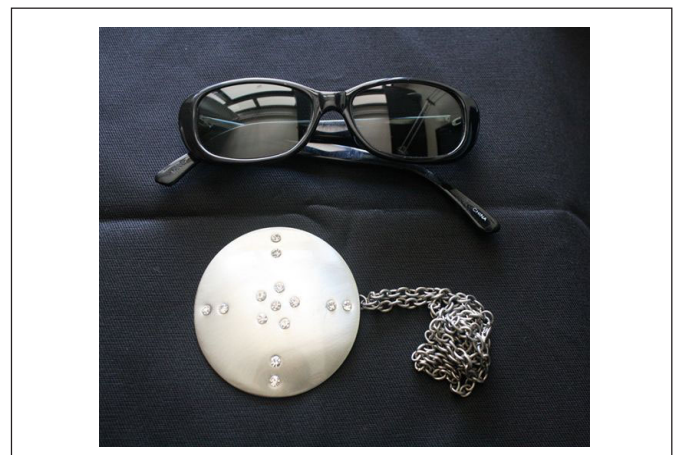
Fig. 2 - Sunglasses and necklace used as adornment.

Once the estimations were concluded and stored, the pictures of the dental arches with metric scale were analyzed, and the mesiodistal dimensions of the upper central incisor were taken with a manual caliper, according to the scale at the picture, as graphically represented in Figure 3. The values obtained from this measuring procedure were then compared to the estimations. All measurements and estimations were made by a single examiner.

Statistical analysis

All measures – real and estimated – were divided in three independent groups, according to the adornment used as reference to the estimation: sunglasses, cap or necklace. For each group, the results were analyzed by Student's t-test for paired samples, with the tooth's real measure and the

$$\frac{\text{TOOTH MEASURE AT THE PICTURE (TMP)}}{\text{ADORNMENT MEASURE AT THE PICTURE (AMP)}} = \frac{\text{TOOTH'S REAL MEASURE (TRM)}}{\text{ADORNMENT'S REAL MEASURE (ARM)}}$$
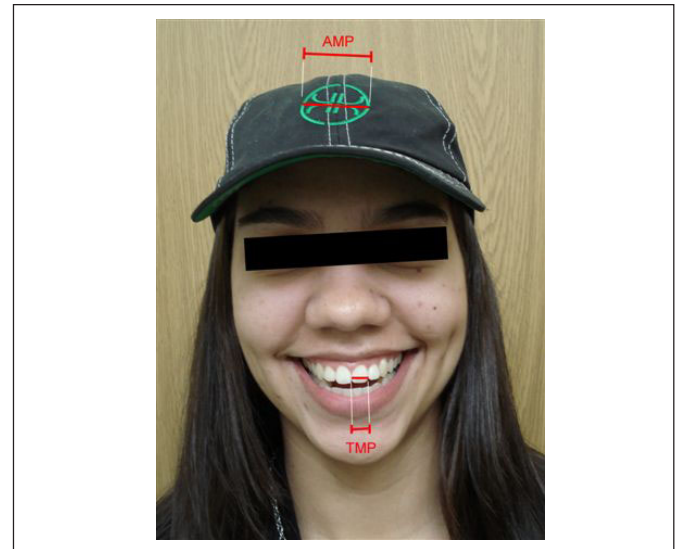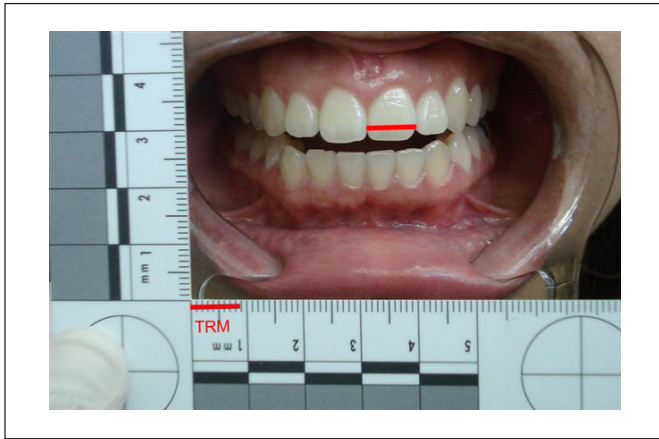
Fig. 3 - Graphic presentation of tooth's real measure (TRM), according to the dental arch's photograph, using a metric scale.

tooth's estimated measure as variables.

Results

The dental dimensions estimated from the size of the cap were overestimated in 100% of the cases, with a mean difference of 0.1867 mm, as can be seen in Table 1. According to the Student's t-test, the estimated dental width was statistically higher than the real width ($p = 0.0000169$), at a significance level of 5%.

When estimating the dental width from sunglass dimensions, overestimated values were found again, except for two cases of underestimation (9.52% of the sample). The mean difference between estimated and real measurements was equal to 0.1190cm, as shown on Table 2. The values estimated from measurements of the sunglasses were considered statistically higher than the actual measurements ($p = 0.0000018$), with a significance level of 5%.

The estimated tooth measures from the dimensional relation with the necklace were overestimated in most cases (92.31%). It is noteworthy that this type of calculation, using the necklace as a reference point, was performed only in female participants, since they have virtual exclusivity in the use of this type of adornment. The mean difference between estimated and actual measurements was equivalent to 0.1262 cm, as shown in Table 3. Tooth measures estimated from the necklace were significantly higher ($p = 0.0001307$) than the actual measurements, with a significance level of 5%.

Discussion

Since the early twentieth century, researchers have analyzed craniofacial correlations and the relationship between the face and the underlying bone morphology. On this line, are noteworthy the studies about the shape of the nose and the nasal bone, as well as variations in nose shapes of different ethnic groups[13-14]. These studies underlie the current principles of facial reconstruction[15], which became the main target for this type of research[16].

As occurs in the nose, eyes also show great relationship between soft tissue and bone structure. The position of ectocanthus was studied by Whitnall in 2,000 skulls, and can be located in the so called tubercle of Whitnall. This anatomical point constitutes the major reference for sizing

Table 1 - Size estimations (in cm) calculated from the cap

Subject	Sex	Tooth measures		Difference
		Estimated measure	Real measure	Estimation – real measure
1	F	0.95	0.9	0.05
2	F	0.82	0.7	0.12
3	F	0.90	0.7	0.2
4	F	1.47	0.7	0.77
5	F	0.96	0.9	0.06
6	F	0.96	0.8	0.16
7	F	0.84	0.8	0.04
8	F	1.03	0.8	0.23
9	F	0.81	0.7	0.11
10	F	0.78	0.7	0.08
11	F	0.86	0.7	0.16
12	F	0.85	0.6	0.25
13	F	1.07	0.8	0.27
14	M	0.93	0.7	0.23
15	M	0.91	0.8	0.11
16	M	0.91	0.8	0.11
17	M	1.08	0.8	0.28
18	M	1.04	0.8	0.24
19	M	0.92	0.8	0.12
20	M	0.88	0.7	0.18
21	M	0.95	0.8	0.15
Mean		0.9486	0.7619	0.1867

Table 2 - Size estimations (in cm) calculated from the sunglasses

Subject	Sex	Tooth measures		Difference estimation – real measure
		Estimated measure	Real measure	
1	F	1.00	0.9	0.1
2	F	0.77	0.7	0.07
3	F	0.93	0.7	0.23
4	F	0.84	0.7	0.14
5	F	0.89	0.9	-0.01
6	F	0.91	0.8	0.11
7	F	0.91	0.8	0.11
8	F	0.92	0.8	0.12
9	F	0.84	0.7	0.14
10	F	0.91	0.7	0.21
11	F	0.63	0.7	-0.07
12	F	0.91	0.6	0.31
13	F	1.00	0.8	0.2
14	M	0.88	0.7	0.18
15	M	0.92	0.8	0.12
16	M	0.88	0.8	0.08
17	M	0.89	0.8	0.09
18	M	0.95	0.8	0.15
19	M	0.85	0.8	0.05
20	M	0.80	0.7	0.1
21	M	0.87	0.8	0.07
Mean		0.8810	0.7619	0.1190

Table 3 - Size estimations (in cm) calculated from the necklace – only female subjects.

Subject	Sex	Tooth measures		Difference estimation – real measure
		Estimated measure	Real measure	
1	F	0.96	0.9	0.06
2	F	0.87	0.7	0.17
3	F	0.89	0.7	0.19
4	F	0.84	0.7	0.14
5	F	0.81	0.9	-0.09
6	F	0.87	0.8	0.07
7	F	0.95	0.8	0.15
8	F	1.01	0.8	0.21
9	F	0.80	0.7	0.1
10	F	0.84	0.7	0.14
11	F	0.88	0.7	0.18
12	F	0.82	0.6	0.22
13	F	0.90	0.8	0.1
Mean		0.88	0.7538	0.1262

and positioning the image of the skull in relation to the face in superimposition methods[15].

The objects used as a dimensional reference in this study were selected because they frequently appear in personal pictures, in the same spatial plane of the teeth. However, the facial sizing from the teeth dimensions naturally requires the recovery of these teeth, which does not always occur, especially considering the frequency of post-mortem loss of anterior teeth.

The proposed method overestimated the mesiodistal width of the central incisor, in its best result – by measuring sunglasses - 1.19 mm on average (15.62% of the real average).

The worst performance was achieved by having the cap as size reference, overestimating the dental width in 1.867 mm on average. The less satisfactory result of the cap in relation to other items may be related to the position of the cap slightly oblique in relation to the plane of the central incisors. Further studies are suggested.

The analysis of a personal photograph for human identification purposes requires excellent image resolution for detailed observation and accurate superimposition with the cranial image. The analysis of teeth in photographs only becomes possible under optimal conditions, close and high resolution images. Still, the use of tooth width as a size

reference, given its small dimensions, creates a greater risk of failure, since fractions of a millimeter can represent important distances in the final result. Thus, when sizing images using anatomical landmarks, the larger the reference, the greater the chance of success.

Although previous studies have been engaged in creating protocols and methods of sizing and positioning skull and face images for superimposition, the correct size and position are more easily achieved through successive attempts, and movement of the images[3,6,1,17-19]. The method evaluated in the present study is therefore inaccurate for sizing facial images for superimposition with human identification purposes.

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