Conjecturas

DOI: 10.53660/CONJ-S21-1189

Two-dimensional facial approximation: facial composite and digital 3D facial approximation techniques applied on cone-beam tomography

Aproximação facial bidimensional: técnicas de retrato falado e de aproximação facial 3D aplicadas em tomografia computadorizada de feixe cônico

Juliana Kern de Moraes[1], Rosane Pérez Baldasso[1,2], Ário Pereira Gonçalves[2], Luciano Beux[2], Mário Marques Fernandes[1], Raíssa Ananda Paim Strapasson[3]*

ABSTRACT

This study aimed to demonstrate two protocols of Two-Dimensional Facial Approximation (2DFA) created with resources of the techniques of Facial Composite and Digital Three-Dimensional Facial Approximation. Both protocols were based on craniometric parameters and their facial correspondence obtained from a Cone-Beam computed tomography of a human skull. After this, this protocols were confronted with a photograph of the target subject. Said techniques, when compared with the photograph of the subject, demonstrated compatibilities and incompatibilities. With the obtained results, it is concluded that the two techniques can to be useful in the process of human facial recognition. Further research on the two protocols is suggested in order to assist the work of forensic professionals in the recognition of unidentified human skulls.

Keywords:

Forensic sciences; Facial approximation; Facial recognition; Forensic anthropology; Facial reconstruction.

[1] Associação Brasileira de Odontologia, Seção Rio Grande do Sul
[2] Instituto-Geral de Perícias do Estado do Rio Grande do Sul
[3] Universidade Federal do Rio Grande do Sul
*E-mail: raissa.strapasson@ufrgs.br

INTRODUCTION

Facial Approximation, popularly called facial reconstruction, is the process of recreating the face of an unknown individual from the skull, merging a variety of knowledge areas, such as Drawing, Sculpture, Anatomy, Anthropology, Osteology, and Dentistry, using methodologies that have been developed for decades and it is considered the most subjective area in the field of Forensic Anthropology. The correspondence between vertical and horizontal facial relationships and facial index applied to populations scientifically supports the execution of facial reconstruction techniques, which can be performed through a drawing, a manual sculpture, or even a computerized sculpture that unites artistic aspects and subjective elements (FRANCO, 2012, p. 2).

The term Facial Approximation was introduced by Robert M. George in 1987, as the author believed that even if the protocols used to recreate the face of the unknown at the time of death were well executed, the result would only "approximate" the appearance of the original face of the individual (GEORGE, 2009).

The human face plays an important role in how we connect and how we remember our ancestors. It is the center of the understanding of personal identity. Facial expressions are one of the oldest and most immediate forms of communication for people. Thus, the intrinsic and distinctive qualities of each face reinforce the existing association between the face and the singular identity (FRANCO, 2012, p. 1). Human facial features are strongly influenced by underlying bone tissue. The bones of the skull are a determining factor of facial appearance, the basic structure where other tissues are connected, composing the appearance of the face. Skulls can remain in good condition for centuries or even thousands of years. They keep valuable information about the appearance of the individual, justifying their use for the facial approximation of a stranger whose bones are the only remains available for analysis (VERZÉ, 2009).

The final characterization of the face is also influenced by individualizing features not related to bone formation, it has a congenital influence or genetic manifestations, such as birthmarks, in addition to acquired ones, such as scars and wrinkles. Facial features are also influenced by ancestry and the cultural group to which the individual belongs. Thus, facial soft tissue thickness is studied according to populations, gender, and age. In Brazil, it is not always possible to have the specific facial features of its population groups in such a clear way, since the traits of the population of the country have significant miscegenation (STRAPASSON; MELANI, 2020, p. 1-2).

Facial approximations in all their forms (clay sculptures, drawings, or digital sculptures) can be presented to the public in a variety of layouts. However, to date, there is no technique considered better than the others by authors in the area. Currently, facial approximations are developed using three main techniques: Manual 2D drawing; Hand 3D Sculpture; Automated 2D and 3D computer modeling (RICHARD; PARKS; MONSON, 2014/2013; MORAES; MIAMOTO, 2015).

As it is an auxiliary method in the human identification process, in practice, the value of the forensic facial approximation stops at the recognition stage, in narrowing an individual's search; producing a list of possible identity names; reducing the number of victims or suspects; reducing DNA testing costs and reducing waiting time for involved families. All facial recognition must be confirmed by some primary method of human identification, suggesting forensic dental analysis or genetic analysis (DNA) in this identification step (STRAPASSON; COSTA; MELANI, 2019; BALDASSO; MORAES; GALLARDO (…), 2020).

Faced with the difficulty of recognizing and identifying the bones found, with the DNA bank still in its initial steps in Brazil, there is a need for techniques that increase the possibilities of recognition by family members.

The present study aims to present two protocols of Two-Dimensional Facial Approximation, ultimately, to subsidize part of the recognition of unidentified individuals.

MATERIALS AND METHODS

This study had a volunteer individual, with a Cone-beam computed tomography (CBCT) of the skull involving the frontal region to the jawline. The study participant did not have facial malformations and/or deformities from large scars.

Four researchers participated in this technique demonstration (referred as Researcher 1, Researcher 2, Researcher 3, and Researcher 4), with only Researcher 1 having knowledge of the volunteer subject's face at the beginning of the study and collecting the frontal image of the subject's skull.

TWO-DIMENSIONAL FACIAL APPROXIMATION WITH FACIAL COMPOSITE TECHNIQUES

Researcher 2, a photographer and forensic artist, who received the frontal images of the skull, one containing the marking on the outer margins of the orbital cavities (bi-orbital width), conducted the facial approximation using facial composite techniques. Researcher 1 described, based on morphological parameters established in the literature, the following bioanthropological profile of the skull to researcher 2: female sex (WALKER, 2008), approximate age of 35 to 40 years (ZAMBRANO, 2005), and predominant traits of European ancestry (HEFNER, 2009).

Researcher 2 carried out the assembly and adjustments of the Two-Dimensional Forensic Facial Representation (2DFFR) from a frontal image, by layers, with the software Adobe Photoshop 2021 (Adobe Systems, California, USA) using the parts (eyes, nose, mouth, ears) from an image bank of Forensic Human Facial Reference commonly formed and constantly supplied by the forensic agencies that perform sketches. The researcher resized the image to true size, using the information from the distance between the outer margins of the eye sockets of 11 cm, which was measured in vivo. As it is a two-dimensional construction, it primarily used the midline points (Supraglabella, Glabella, Nasion, Rhinion, Nasospinale, Prosthion, Infradentale, Pogonion, and Gnathion) (MORAES; MIAMOTO, 2015; HERRERA; STRAPASSON; SILVA; MELANI, 2016).

COMPUTERIZED TWO-DIMENSIONAL FACIAL APPROXIMATION

Researcher 3, an official expert trained to perform digital facial approximations, processed the images of the CT skull and created the 3D mesh, performing the Three-Dimensional Digital Facial Approximation. The computed tomography images were imported into the Blender software version 2.75a (Blender Foundation, Amsterdam), using the OrtogonBlender5 add-on – Forensic option – CT Scan Reconstruction with the Default option. The image processing by the software resulted in three-dimensional meshes of soft tissues (SoftTissue), teeth (Teeth), and bones (Bones), the first two being discarded, working only on the Bones mesh.

Subsequently, the soft tissue markers were imported with the application of the bioanthropological data of the target individual: the mesh was scaled through the actual measurement between the right and left ektokonchion points and aligned according to the Frankfurt horizontal plane. Then the soft tissue marking points (MORAES; MIAMOTO, 2015) were imported and positioned, using the add-on, following the values determined according to the estimated bioanthropological profile, considering the morphological information observed in the skull and already described: female sex, European ancestry, and mean age of 35 to 40 years. For this purpose, values referring to the individual's sex, ancestry, age group, and Body Mass Index (BMI) were used (MORAES; MIAMOTO, 2015; WALKER, 2008; ZAMBRANO, 2005; HEFNER, 2009). As researcher 3 did not have the target individual's BMI data, an ideal mean BMI was considered for facial approximation.

To mark the facial structures and ears, and to create a 3D model, a projection of the midline was created; the eyes were imported with the help of the add-on; projections and markings of the nose, lips, eyebrows, and ears were made and the positioning of muscle structures were imported, whose shapes are predefined by the add-on; however, these were adjusted and sculpted for proper insertion into the mesh of the skull. Then, a mesh was generated to sculpt the face, performed using the tools and features of the Blender software, obeying the limits imposed by the soft tissue markers and projections/traces previously performed. The human model was imported into the MakeHuman software version 1.0.2 (The MakeHuman Team, California, USA), in which the final adjustments were made, creating a human model consistent with the bioanthropometric data of the target individual, with the face adjusted according to a mask created by rendering the bone and muscle structures. The human model was then imported into the Blender software, with the help of the add-on, being modeled and sculpted so that the face would adapt to the sculpting mesh and the final result was rendered in frontal, orthographic view.

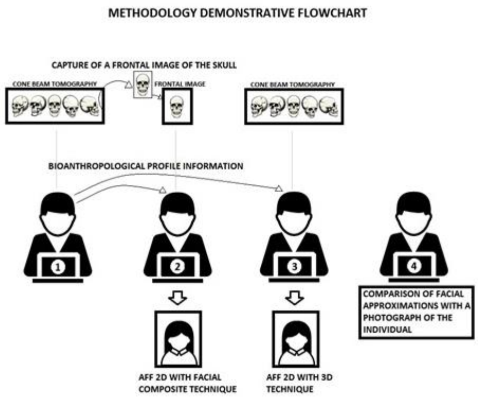
COMPARISON OF FACIAL APPROXIMATIONS AND PHOTOGRAPH OF THE TARGET INDIVIDUAL

Researcher 4, an official expert with no contact with previous study data, was responsible for this step. The researcher performed the visual comparison of the images and the analysis of the results obtained, between the two compositions performed (two-dimensional facial approximation using the digital facial composite technique and two-dimensional facial approximation using the digital 3D facial approximation technique) with a photograph of the face of the study participant within the standards established by the International Civil Aviation Organization (ICAO). The visual morphological and morphometric analysis, as recommended by the Facial Identification Scientific Working

Group (FISWG) was performed, as well as the overlaying of scaled images using the ImageJ image analysis and processing software version 1.46r (National Institutes of Health, Maryland, USA).

The flowchart below (Figure 1) illustrates the main steps of the methodology:

Figure 1 – Flowchart outlining the methodology used in the study.



Source: Macrovector-Freepik and PNGWING

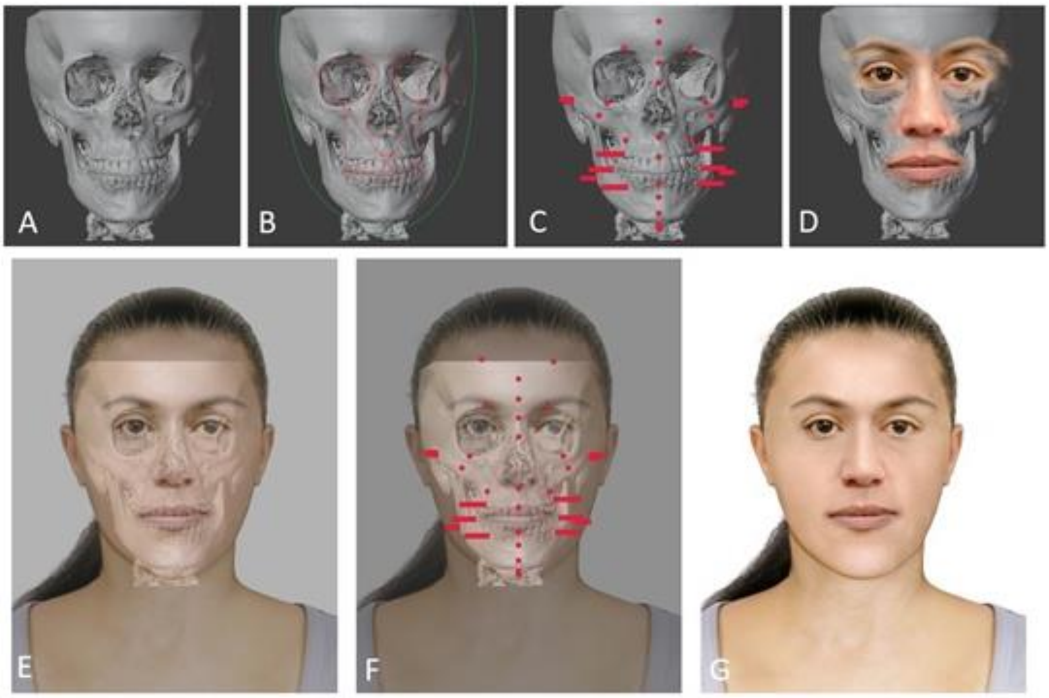
ETHICAL ASPECTS

This study was carried out after approval by the Research Ethics Committee of the Faculty of Dentistry of the Federal University of Rio Grande do Sul (UFRGS), and the procedures were carried out under approval protocol number 4678338. There was no conflict of interest in carrying out this research.

RESULTS

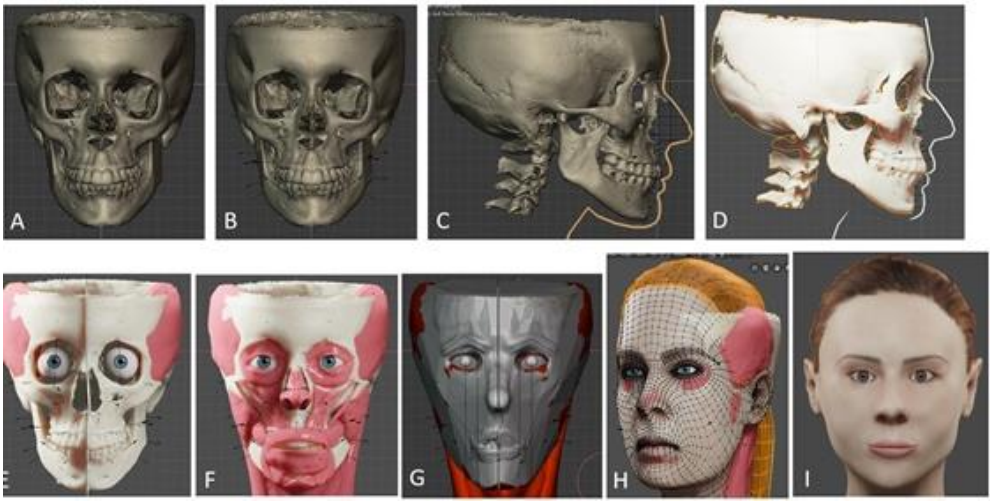
From a frontal image captured from the CT Cone Beam of the target individual, researcher 2 composed the Two-Dimensional Facial Approximation shown in Figure 2.

Figure 2 – Two-dimensional facial approximation with facial composite techniques. A. Frontal image of the CT skull; B. Image resizing; C. Marking of craniometric points; D. Application of face image segments from the database; E. The first layer applied over the CT skull; F. Composition comparison with craniometric points; G. Final composition.



Based on the CT Cone Beam images of the target individual imported into the Blender software, researcher 3 composed the Three-Dimensional Facial Approximation, having captured a two-dimensional image of the facial approximation performed (Figure 3).

Figure 3 – Three-dimensional facial approximation. A. Tomography recreated in a virtual environment through a Bones mesh in Blender software; B. Mesh scaling by the actual measurement between the Ektokonchion craniometric points, alignment to the Frankfurt Plane and addition of the soft tissue marking points; C. Insertion of soft tissue markers according to the individual's bioanthropological profile; D. Demarcation of facial structures, nose projection and lighting adjustment; E. Demarcation of the midline, importing the eyes, marking the nose, lips, eyebrows and ears and the import and positioning of muscle structures; F. Modeling of muscle structures according to the mesh; G. Human model performed in MakeHuman software, using rendering of bone and muscle structures; H. Import into Blender software, modeling, and sculpting so that the face adapts to the face sculpting mesh; I. Human model rendered in orthographic front view.



The comparison between the Two-Dimensional Facial Approximation using Facial Composite techniques and the frontal photograph of the individual's face reached the following results (Figure 4):

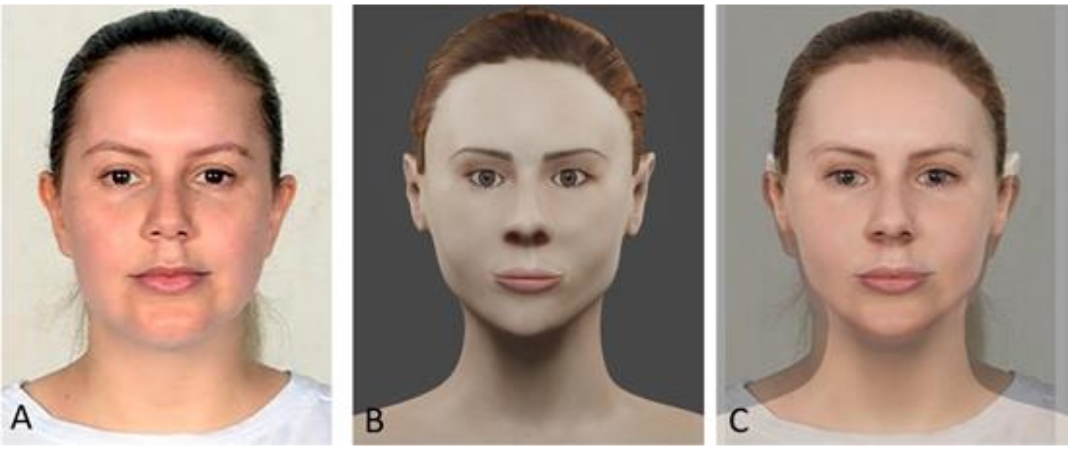
Figure 4 – Comparison with the two-dimensional facial approximation performed with composite techniques. Scaled images. A. Image of the frontal photograph of the individual's face; B. Forensic Facial Representation – Facial Composite; C. Overlaying images.

Areas of incompatibilities: a) shape of the cranial vault - frontal contour; b) capillary insertion line; c) length of the ears; and d) jawline.

Areas of compatibility: a) dolichofacial biotype, with an oval appearance; b) position of the eyebrows; c) position of the eyes; d) height of the ears; e) position of the base of the nose; and f) position of the buccal cupid's bow;

The comparison between the Two-Dimensional Facial Approximation using Digital Three-Dimensional Facial Approximation techniques and the standard ICAO photograph of the individual reached the following results (Figure 5):

Figure 5 – Comparison with two-dimensional facial approximation performed with digital 3D facial approximation techniques. Scaled images. A. Image of the frontal photograph of the individual's face; B. 3D forensic facial approximation; C. Overlaying images.



Areas of incompatibilities: a) brachyfacial biotype; b) capillary insertion line; c) position of the eyebrows; d) height of the ears; and e) jawline.

Areas of compatibility: a) shape of the cranial vault – frontal contour; b) position of the eyes; c) position of the base of the nose; and d) Cupid's bow position.

Table 1 summarizes the results of the comparison of facial approximations performed in the study with the ICAO standard photograph of the target individual.

Table 1 – Comparative table between the results of the collation of the two-dimensional facial approximation performed with the techniques of the facial composite and the two-dimensional facial approximation performed with the techniques of digital 3D facial approximation with the photograph of the individual.

Facial Composite		3D technique	
Incompatibilities	Compatibilities	Incompatibilities	Compatibilities
The shape of the cranial vault – frontal contour	Dolichofacial biotype - oval	Brachyfacial biotype	The shape of the cranial vault – frontal contour
Capillary insertion line	Eyebrow position	Capillary insertion line	Eye position
Length of ears	Eye position	Eyebrow position	Nose base position
Jawline	Ear height	Ear height	Mouth cupid's bow position
	Nose base position	Jawline	
	Oral cupid's bow position		

DISCUSSION

After the composition of two forensic facial approximations with different techniques, by two different researchers, the comparison and analysis of the images confronted with a standardized frontal photograph of the face of the individual participating in the study were performed.

The comparison between the Two-Dimensional Facial Approximation using Facial Composite techniques and the frontal photograph of the individual's face demonstrates incompatibilities and compatibilities. In a first view, it can be seen that the facial composite is not adjusted to the Frankfurt plane, which can generate some explainable differences when superimposed with the photograph. Despite these, the facial approximation has a correct dolichofacial biotype, with an oval appearance of the face. The morphological and morphometric analysis demonstrates alteration in the shape of the cranial vault - frontal contour and the capillary insertion line, and in the two-dimensional facial approximation, these regions were underestimated in height. This fact is justified by the difficulty or even impossibility of predicting capillary insertion, as well as other facial structures (hair color and type, eye color) in a completely skeletonized skull. Furthermore, although cone-beam computed tomography is a good choice for research in the area of facial approximation – as it allows the measurement of craniometric and even facial data in an upright rather than supine position like traditional medical CTs, and with lower radiation dose (CLAES; VANDERMEULEN; GREEF; WILLEMS, 2010), presents a limiting factor as it often does not reach the area above the forehead, causing a bias that underestimates the frontal contour (cranial vault height).

In the comparison, the position of the eyebrows and eyes can be highlighted, which is very similar between the two images, although it is impossible to predict the color and often the shape of both structures. Another relevant observation is the length of the ears, which, although showing similar height, imply a change in size.

The position of the base of the nose is the same between the two images; however, the tip of the nose differs being higher in the photograph. This can be explained by the difficult prediction of the size and shape of the facial soft structures when only the dry skull is observed. This difficulty is reported by several authors and previous studies have shown that nose reconstruction is routinely inaccurate. This is probably related to the fact that the nose consists mainly of cartilaginous tissue and little bone support to reference the estimate of its morphology (CLAES; VANDERMEULEN; GREEF; WILLEMS, 2010). It should be noted that the research participant stated that he had some facial changes due to aesthetic procedures such as botulinum toxin application and hyaluronic acid filler. One of the procedures that the individual underwent was the application of botulinum toxin in the depressor nose muscle, which may explain the elevation of the tip of the nose.

Currently, facial alterations performed for aesthetic purposes, such as plastic surgeries, such as rhinoplasty, and procedures considered less invasive, such as botulinum toxin and fillers, have worried researchers in the forensic field. It is believed that such modifications may interfere with facial recognition in some situations, especially when skeletonized skulls are compared with faces whose photographs before the procedures are unknown. Nappi et al., in 2016, presented a summary of the main facial plastic surgeries and facial aesthetic procedures with their most frequently involved areas, the extent of the affected region, the extent of impact normally expected on the alteration of appearance, and the percentage of diffusion of each procedure concerning the total number of procedures performed in a year (NAPPI; RICCIARDI; TISTARELLI, 2016). In the 2016 study, it is observed that the application of botulinum toxin, most widely used on the forehead, causes a potential impact, considered by the authors, of low to medium on the appearance of the face; and facial fillers, most used in smile lines and periocular region, cause a potential impact considered to be medium (NAPPI; RICCIARDI; TISTARELLI, 2016).

In the present study, the mouth was very similar, mainly due to the height of the cupid's bow in the comparison of the images. However, due to the use of lip fillers, there is also not enough evidence to deliberately state that the mouth follows the same proportion. Despite this, it presented an adequate position.

Finally, the jawline showed a great difference, being quite prominent in the photograph, which is not the case with the facial composite. The differences between the composite and the photograph probably derive from the difficulty in predicting the soft facial structures, such as ears, nose, mouth, and eyes. Russian anthropologist Gerasimov was one of the first to perform manual reconstruction by modeling the complete anatomy of facial muscles and soft tissues covered by a thin layer, mimicking skin, over the skull (Russian method of facial approximation). Currently, population standards of soft tissue thickness are used for each point (CLAES; VANDERMEULEN; GREEF; WILLEMS, 2010). These thickness patterns vary between populations, such as ancestry, sex, age, and body mass index (BMI).

An individual's soft tissue envelope can be influenced by their BMI, as demonstrated by DeGreef e col. (2009) in Short *et al*, 2014, in which they observed that the cheek and jaw areas are most influenced by BMI. This study demonstrated that a change in BMI score of 10 will have an effect of about 4 to 5 mm on soft tissue depths in some regions. This effect, in the individual's facial contour, can translate changes that make recognition difficult. An individual's soft tissue envelope will never be completely accurate as soft tissue is extremely variable between individuals and there will always be people who do not fall within the population mean data range that does (SHORT; KHAMBAY; AYOUB; EROLIN (…), 2014). Additional crime scene information may be used to help against this difficulty in predicting BMI. When a suspicious bone is close to the victim's belongings, evidence found at the crime scene, such as clothing, can be helpful (CLAES; VANDERMEULEN; GREEF; WILLEMS, 2010).

Another factor to be pointed out in the facial composite technique is that the human artist has an implicit conscience based on the observation of many faces during his life, mainly in forensic work, in addition to the anatomical and artistic knowledge proposing a subjective result (CLAES; VANDERMEULEN; GREEF; WILLEMS, 2010). It is similar to manual modeling, but with the difficulty of visualization in only two dimensions. The interpretations of two different artists always result in the creation of two different faces, where the differences may vary widely. According to Davy *et al*, in Clement and Marks, (online), multiple facial reconstructions of various victims of the Green River serial killer were created and the results were highly variable and little success was achieved when shown to the population (CLEMENT; MARKS, online; HAGLUND; REAY, 1991). This obstacle could be circumvented by creating multiple compositions of the same skull using different assumptions (BMI, eye color, etc.)

Progress in computer science and improvement in medical imaging technologies over the past few years has led to the development of alternative methods for facial approximation. A computer always generates the same data output. Furthermore, procedures can be automated so that multiple reconstructions of the same skull can be created, using different modeling assumptions (age, BMI, ancestry, etc) (ANUÁRIO BRASILEIRO DE SEGURANÇA PÚBLICA). Even free software can be used, which is capable of producing 3D facial reconstructions with plausible levels of accuracy and similarity (BALDASSO; MORAES; GALLARDO (…), 2020).

In this way, the present study also brings a comparison between the photograph and a forensic facial approximation performed with digital three-dimensional techniques, using public domain software. When comparing the images, similarities and differences can be noted. In morphological and morphometric analysis, it can be observed that the capillary insertion line is different from the photograph, in the collation, it is observed that the line is lower in the composition of the facial approximation than in the photograph of the individual, despite the shape of the cranial vault – the frontal contour is almost exactly between the two images. This difficulty is certainly due to the restriction imposed vertically by the tomography, and because it is typically difficult to predict the pattern of baldness in skeletonized individuals. This observation differs from the facial approximation made with the facial composite techniques since Researcher 2 receives a two-dimensional image and researcher 3 works three-dimensionally with the skull. It should be noted, however, that cone beam tomography did not capture the forehead ridges, and this may explain the difference in the position of the eyebrows, very low in the two-dimensional facial approximation with 3D techniques.

The position of the eyes in the two images demonstrated accuracy in the comparison, as well as the base of the nose and the position of the Cupid's bow. Again, without being able to predict colors, exact shape, and volume in the 3D facial approximation technique.

The height of the ears again demonstrates difficulties in reaching accuracy, being very high in the three-dimensional facial approximation. This corroborates the literature whether the means used in facial approximation, artistic or computerized, the accurate assessment of the nose, ears, eyes, and hair will always be problematic, in this way the artist will always have the role of "humanizing" the face (VANEZIS; BLOWES; LINNEY (…), 1989). Several studies suggest techniques based on bone structures and population variations, but studies in the area are still needed to compensate for the difficulties in predicting facial structures (STRAPASSON; COSTA; MELANI, 2019; VANEZIS; BLOWES; LINNEY (…), 1989).

Finally, attention is drawn to the brachyfacial biotype and the reduced jawline with a sharp chin in facial approximation, which is not the case in the photograph of the individual. As already mentioned, the use of the three-dimensional technique facilitates the visualization of bone structures, but the BMI was not adequately predicted by the technique, due to what has been previously justified.

Facial Approximation is the process of recreating the face, from an individual's skull, merging a variety of areas of knowledge. It is the last resort to be used in cases of skulls without probable identities and should not be used indiscriminately, requiring the support of primary identification methods after facial recognition (GEORGE, 1987; BALDASSO; MORAES; GALLARDO (…), 2020).

In practice, the value of forensic facial approximation (FFA) is limited to the recognition stage, which can narrow the search for an individual; produce a list of names; reduce the number of victims or suspects; reduce DNA testing costs and reduce waiting time for involved families. This potential, even if subjective, can be considered important, at a time when there is no knowledge to which family the bone belongs to carry out the DNA test, since, in Brazil, there is a still incipient sample bank. According to the 2021 Brazilian Public Security Yearbook, in 2020, 62,857 disappearances were recorded (ANUÁRIO BRASILEIRO DE SEGURNAÇA PÚBLICA). In June 2021, the National Bank of Genetic Profiles had 4,047 unidentified remains (MINISTÉRIO DA JUSTIÇA E SEGURANÇA PÚBLICA - BRASIL). In this context of many missing people today in the country, simple and inexpensive methods are needed to narrow the search, to nominate a family to carry out the recognition and execution of laboratory tests, in addition to enabling the filing of dental documentation for comparison.

It is emphasized, once again, that the Facial Approximation is not a primary method of human identification, but, rather, a resource of great value in the narrowing of the search that has the purpose of individual recognition, leading to the final objective of human identification through the specific execution of primary tests (dental or genetic) to establish (or not) the identification of a missing individual.

CONCLUSION

It is concluded that both Forensic Facial Approximation techniques demonstrated have facial recognition potential. Thus, further research is needed on both Two-dimensional Facial Approximation protocols to assist in the work of forensic professionals in the recognition of unidentified individuals.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the translator André Marques Santos for the assistance in the final adjustments of this paper.

REFERENCES

BALDASSO, R. B., MORAES, C., GALLARDO, E., STUMVOLL, M. B (...). 3D Forensic Facial Approximation: Implementation Protocol in a Forensic Activity. **Journal of Forensic Sciences**, v. 66, n. 1, p. 383-388, 2020.

CLAES, P., VANDERMEULEN, D., DE GREEF, S., WILLEMS, G., CLEMENT, J. G., SUETENS, P. Computerized craniofacial reconstruction: Conceptual framework and review. **Forensic Science International**, v. 201, n. 1-3, p. 138-145, 2010.

CLEMENT, J.G., MARKS, M.K. Computer-Graphic Facial Reconstruction. New York: **Elsevier Academic Press**, p 183-196. ISBN 9780124730519 (Print), 9780080454221(Online). https://www.elsevier.com/books/computer-graphic-facial-reconstruction/clement. Acesso em: 16 junho de 2021.

FISWG. Facial Identification Scientific Working Group. Disponível em: **www.fiswg.org** Acesso em: 16 junho de 2021.

FÓRUM BRASILEIRO DE SEGURANÇA PÚBLICA. **Anuário Brasileiro de Segurança Pública**. **Ano 15.** p. 1-380, 2021. Disponível em: https://forumseguranca.org.br/anuario-brasileiro-seguranca-publica. Acesso em 19/10/2021.

FRANCO, J. M. B. Aproximação Facial De Quatro Crânios Da Coleção Osteológica Luís Lopes. DISSERTAÇÃO MESTRADO EM ANATOMIA ARTÍSTICA. **Repositório**. Lisboa: Universidade de Lisboa, 2012 p. 1-286.

GEORGE, R. M. The Lateral Craniographic Method of Facial Reconstruction. J **Forensic Science,** v. 32, n. 5, p.1305-1330, 1987.

HAGLUND, W., REAY, D. Use of facial approximation techniques in identification of green river serialmurder victims**. American Journal Forensic Medicine & Pathology,** v.12, n. 2, p. 132-142, 1991.

HEFNER, J. T. Cranial nonmetric variation and estimating ancestry. **Journal of Forensic Sciences**, v. 54, n. 5, p. 985-995, 2009.

HERRERA, L. M., STRAPASSON, R. A. P., SILVA, J. V. L., MELANI, R. F. H. Forensic facial approximation assessment: can application of different average facial tissue depth data facilitate recognition and establish acceptable level of resemblance? **Forensic Science International**, v. 266, n. 1, p. 311-319, 2016.

ICAO. International Civil Aviation Organization - Doc 9303. Disponível em: **http://www.icao.int/publications/pages/publication.aspx?docnum=9303** Acesso em: 16 de junho de 2021.

MINISTÉRIO DA JUSTIÇA E SEGURANÇA PÚBLICA. Disponível em: **https://www.gov.br/mj/pt-br** acesso em 19/10/2021.

MIRANDA, G. E., WILKINSON, C., ROUGHLEY, M., BEAINI, T. L., MELANI, R. F. H. Assessment of accuracy and recognition of three-dimensional computerized forensic craniofacial reconstruction. **PLoS ONE**, v. 13, n. 5: e0196770, 2018.

MORAES, C., MIAMOTO, P. **Manual de Reconstrução Facial 3D Digital** - Aplicações com código aberto e software livre. 1ª ed. Expressão Gráfica, 2015.

NAPPI, M., RICCIARDI, S., TISTARELLI, M. Deceiving faces: When plastic surgery challenges face recognition. **Image and Vision Computing**, v. 54, n.1, p. 71-82, 2016.
PARKS, C. L., RICHARD, A. H., MONSON K. L. Preliminary performance assessment of computer-automated facial approximations using computed tomography scans of living individuals. **Forensic Science International**, v. 233, n. 1-3, p. 133-139, 2013.

RICHARD, A. H., PARKS, C. L., MONSON, K .L. Assessment of presentation methods for ReFace computerized facial aproximations. **Forensic Science International**, v. 242, p. 283-292, 2014.

SHORT, L. J., KHAMBAY, B., AYOUB, A., EROLIN, C., RYNN, C., WILKINSON, C. Validation of a computer modelled forensic facial reconstruction technique using CT data from live subjects: A pilot study. **Forensic Science International**, 237:147.e1–147.e8, 2014.

STRAPASSON, R. A. P., COSTA, C., MELANI, R. F. H. Forensic Facial Approximation: Study of the Nose in Brazilian Subjects. **Journal Forensic Science**, v. 64, n. 6, p. 1640-1645, 2019.

STRAPASSON, R. A. P., MELANI, R. F. H. Facial reconstruction: Validation of the Tedeschi-Oliveira method for estimating the pronasale point in Brazilians. **Brazilian Oral Research,** 34:e09, 2020.

VANEZIS, P., BLOWES, R. W., LINNEY, A. D., TAN, A. C., RICHARDS, R., NEAVE, R. Application of 3-D computer graphicsfor facial reconstruction and comparison with sculpting techniques. **Forensic Science International**, v. 42, n. 1-2, p. 69-84, 1989.

VERZÉ, L. History Of Facial Reconstruction. **Acta Biomedica**, v. 80, n. 1, p. 5-12, 2009.

WALKER, P. L. Sexing skulls using discriminant function analysis of visually assessed traits. **American Journal Physical Anthropology**, v. 136, n. 1, p. 39-50, 2008.

ZAMBRANO, C. J. Evaluation of regression equations used to estimate age at death from cranial suture closure. MASTER OF SCIENCE THESIS. **University of Indianapolis**, Indianapolis, 2005 p. 1-75.

Recebido em: 20/05/2022

Aprovado em: 23/06/2022

Publicado em: 02/07/2022