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Forensic Facial Reconstruction: Review and Analysis of Scientific Research in Brazil

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Abstract. Forensic Facial Reconstruction (FFR) refers to any process that aims to recover the morphology of a face at the moment before death, from the observation of a skull. It's a recognition method that allows direct investigations for primary methods of human identification. The literature on this topic is very extensive, however, there are only few national studies, even in Forensic Dentistry. The present study aimed to review and to analyze the Brazilian research publications about FFR. On April 13, a search for references was carried on Bibliografia Brasileira de Odontologia (BBO) and Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS) electronic full-text databases with the terms "forensic facial reconstruction", "forensic facial reconstitution" and "forensic facial approximation". A total of 10 national references was found, between 2000 and 2012: 2 articles, 3 dissertations and 5 theses. Most of the references belong to the field of dentistry and the topic that was most studied is facial soft tissue thickness of Brazilian subjects, totaling 30% of the publications. About 50% of the studies have been made since 2010, which shows that the national studies are recent. We conclude that the Brazilian literature on FFR has been growing, but there is still a lack of research. The preparation of theses and dissertations is valuable for the development of Forensic Sciences and Forensic Dentistry.

Keywords: Forensic sciences, Forensic anthropology, Forensic dentistry, Human identification, Face.

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1. Introduction

The identification of human remains represents a major challenge in forensic sciences. It is crucial not only to return the remains to the family for proper mourning and acceptance of death, but also for legal action relating to death[1-2].

Forensic Facial Reconstruction (FFR) refers to any process that aims to recover the morphology of a face at the moment before death, from the observation of a skull[3-5]. It allows recognition and assists the process of human identification when it is not possible to obtain optimal conditions, as a comparison of ante-mortem and post-mortem data.

Regarding techniques, they can be two-dimensional (2D), three-dimensional (3D) manual and three-dimensional (3D) digital. All of them are dependent on the estimate of soft tissue thickness that covers the face. This thickness, in turn, is variable according to gender, age and ancestry[6,7].

To perform an RFF, the scientific literature recommends the use of information of the ethnic group to which the skull belongs. Several researchers worldwide have made studies about the average thickness of soft tissue for various populations and ethnic groups: German[8], American White[2,7], American Black[9], Chilean[10], Chinese[11], Korean[12], European[3], Japanese[13], South African[14], Turkish[15], among others.

The mean values of soft tissue thickness may be obtained by different methods. Measurements made directly on cadavers, by puncturing the skin with needles, were initially proposed by His in 1895[7,16]. With the evolution of imaging exams used in medicine and dentistry, new parameters for these measures could be obtained.

Although tables, with average thickness of facial soft tissue on craniometric predetermined points act as guides of facial contours, the tip of the nose, the lips, the eyes and ears are difficult to determine from the skull, and these are important features for face recognition[17]. Some studies[18-19] was conducted in a Chilean population to assess the nose's shape in relation to sex. In Italy, the dimensions of nose, ear and lips were analyzed in relation to sex and growth changes between childhood and old age[20-22]. Some of these external anatomical parameters were different in relation to age and sex.

Manual reconstructions are still widely used in forensic science. However, new computer resources have provided the opportunity to obtain multiple representations of a subject in a quick and easy way[5,16,23].

The first computer technique applied on FFR was developed by Vanezis et al. in 1989[2,16]. The authors performed manual and computer facial reconstructions of a known skull, and then compared the final results with a photograph of the individual to whom the skull belonged. The results showed that the computer techniques, at that moment, were as efficient as manual techniques. Later, Nelson and Michael in 1998 developed a new method of computer facial reconstruction called "Volumetric Deformation". With this method, it was possible to leave the reference tables of soft tissue thickness and use only the data of facial volumes. However, the method uses only one face and all the reconstructions may be similar to that face, even when taking into account the direction given by the shape of each skull bone, which is individual[16].

Claes et al.[5] claimed that the current computer techniques have the same general workflow. First, the unknown skull is examined for information on gender, age, height and ancestry. Then, a virtual copy of the skull is obtained by digitizing the real skull. Then, a cranio-facial model is chosen based on databases, which encodes the knowledge about the relationship between the face and the bone tissue. This model is equivalent to performing a manual reconstruction by an operator. Facial reconstruction is then obtained by geometric relationship between the cranio-facial model and virtual copy of the skull. In a final stage, texturing can be added to the reconstruction, generating images for subsequent dissemination and recognition.

In order to realize digital facial reconstructions, one study[23] in the United Kingdom used cone-beam Computerized Tomography (CT) of three Korean subjetcs. The results showed that the 3D modeling method is able to produce reliable computerized facial reconstructions. Computer-aided facial reconstruction was also used in studies in France and showed good results[24].

The literature about FFR is quite extensive and is increasingly growing because of advances in computational methods. However, the National Forensic Dentistry is a recent investigated area and few studies on this topic are found in Brazil. So, this study aimed to review and analyze the Brazilian research publications about FFR.

2. Materials and Methods

On April 13, a search for references was carried on two electronic full-text databases - Bibliografia Brasileira de Odontologia (BBO), available at: http://www.bireme.br and Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), available

at: http://www.lilacs.bvsalud.org - with the terms “facial reconstruction”, “forensic facial reconstruction”, “forensic facial reconstitution” and “forensic facial approximation”. The databases were chosen according to comprehensiveness and accessibility criteria. Extended research including theses and dissertations of USP, UNESP and UNICAMP digital libraries. Only studies with national samples were included.

Time period wasn’t established since FFR has been studied in Brazil for a short time and can be identified in its totality. Studies addressing artistic or archaeological facial reconstruction were not included.

Therefore, after identifying and reading the papers, it was attempted to classify them according to the type of production, subject matter, area of knowledge in which each study was made and year of publication.

3. Results

The searches in electronic databases and digital libraries used in this study allowed us to recover more than 100 Brazilian references to the terms described in Materials and Methods. The results in Frame 1 show the distribution of number of references obtained for each search term used in each data base and library.

Frame 1. Distribution of publications in different databases with search terms.

	BBO	LILACS	USP	UNESP	UNICAMP
Facial Reconstruction	56	115	6	4	10
Forensic Facial Reconstruction	5	4	3	0	0
Forensic Facial Reconstitution	1	2	0	0	1
Forensic Facial Approximation	0	0	0	0	0

By analyzing the references obtained with the term "Facial Reconstruction" it was realized that most of them did not refer to the forensic science but to such fields as surgery and orthodontics. Then, It was decided to minimize the survey using only the terms "forensic facial reconstruction", "forensic facial reconstitution" and "forensic facial approximation". The total national production of FFR was 10 studies, most of which consists of theses (Table 1).

Table 1. Distribution by type of production.

Type of production	N	%
Article	2	20
Dissertation	3	30
Thesis	5	50
Total	10	100

Regarding the subject matter, there was a higher concentration in the study of soft tissue thickness of Brazilian faces, as shown in Table 2.

Table 2. Distribution of productions by subject.

Subject	N	%
Evaluation of the accuracy of measurements in CT	1	10
Evaluation of digital FFR	1	10
Computer graphics in FFR	1	10
Thickness of facial soft tissue	3	30
Average facial masks for Brazilian people	1	10
Laboratory for FFR research	1	10
Location and setting craniometric points	1	10
Nasal projection	1	10
Total	10	100

With respect to the area of knowledge, the production could be divided into three areas, and the Dental Area had the highest concentration of references (Table 3).

Table 3. Distribution of production in relation to the area of knowledge.

Area of knowledge	N	%
Bioengineering	1	10
Medicine	2	20
Dentistry	7	70
Total	10	100

The production was also classified according to the year of publication, as shown in Table 4. A higher concentration of references is observed in 2008 and 2010.

Table 4. Distribution of production according to the year of publication.

Year of publication	N	%
2000	1	10
2001	-	-
2002	-	-
2003	1	10
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	3	30
2009	-	-
2010	3	30
2011	1	10
2012	1	10
Total	10	100

4. Discussion

The knowledge of research on a subject at a certain period of time is important for the process of scientific evolution. The survey information and results allow us to check what is being produced to discuss new ideas and identify the necessary complementary approaches.

By analyzing the data obtained we noticed that the scientific production in FFR is new in Brazil. Only 10 national references have been found in the last 13 years, and 50% have been found since 2010, as shown in Table 4. There is a predominance of dissertations and theses, especially in the field of dentistry (Tables 1 and 3). According to Rocha et al.[25] the studies of craniometric characteristics are closely connected to forensic dentistry. Santos et al.[26], who investigated data of the correct location of craniometric points in Magnetic Resonance Images (MRIs) to FFR, stated that it is required a suitable knowledge of dental anatomy for locating points on the bone surface. These observations, therefore, justify the occurrence of most of the work on FFR in the field of dentistry.

The oldest work found was a thesis, dated 2000 (Table 4), and refers to the creations of two face masks for a particular ethnic group of the population (mesoprosopic caucasian), one for males and one for females, through a facial mapping laser technology. These masks can be superimposed on CT scans of a

found skull and readapted to the bone surface. The author explained that the application of facial masks is reduced in Brazil, due to the high rate of population miscegenation. He also said that the country, due to its social and economic situation at that time, would continue performing FFR through traditional methods and using international tables of soft tissue thicknesses[6].

In Table 2, we noticed that, despite several issues, the determination of facial soft tissue thickness of Brazilians was the most present one, corresponding to 30% of the research in RFF today. The interest in determining these average facial values occurred only after the year 2008, due to the need to employ specific data of the population in forensic reconstructions (Table 4). These studies involved direct measurements of soft tissue thickness by puncturing the skin with a fine needle and bulleted silicone in cadavers as well as measurements on MRI scans of living individuals[7,27-28]. The averages obtained in these studies were different from other populations. However, it is observed that the determination of values for Brazilian faces is not consolidated yet. There are three different soft tissue thicknesses tables and is not established in any protocol which of them to use.

It is indisputable that measures of great accuracy are achieved through imaging tests such as CT scans and MRIs, but the use of tables derived from cadavers does not imply less accurate reconstruction.

Another important point is the determination of anatomical external parameters in aid of FFR. It was observed that only Tedeschi-Oliveira[17] helped in this endeavor by presenting a nasal projection technique for reconstructions of Brazilian individuals (Table 2). The study sought to relate the prosopometric points Rhinion (located in the bone), Pronasale (located in the soft tissue) and Prosthion (also located in the bone) by studying the angle formed by the lines that unite them, noting the possibility of using it to estimate the nasal length. It was demonstrated that the use of 90° value for the angle Rhinion-Pronasale-Prosthion can assist in the determination of nasal projection of Brazilian adults. Because there are no research involving other structures of Brazilian subjects, such as lips, ears and orbital area, to complement FFR, it is suggested that studies in anthropometry check morphological variations and estimate matches in skull so these structures can be reconstructed.

For the studies reviewed, it can be said that computerized FFR is beginning in Brazil. There are only two papers on computerized three-dimensional facial reconstructions. The first one was done in 2010 (Table 2). The studies basically used computerized tomography images imported in software, which served as a virtual

environment to reconstruct the soft tissues through craniometric points and predetermined thickness soft tissue data[2,29].

There is an increasing use of CT scans in forensic studies. In 2003, a study on craniometric measurements on CT scans, for identification purposes, proved that it was possible to apply this information in FFR[25]. Measurements of soft tissue thicknesses may also be conducted in CT scans, as an additional resource in obtaining this information. In manual FFR, the scans may be useful for skull copies when associated with the original three-dimensional printers. For computerized facial reconstructions, these imaging examinations are essential and this was observed in national studies that have addressed this technique.

It is expected that, in the future, fully automated reconstructive methods, which are a reality in other countries, can be developed and validated in Brazil. In the meantime, the research can be conducted to simpler and easy to access methods, for example, by obtaining three-dimensional models using digital photography, allowing even the abandonment of CT scans, which are costly.

Currently, the Laboratory of Anthropology and Forensic Dentistry (OFLab) from Faculty of Dentistry (FO) - University of São Paulo (USP) is conducting research into various themes, including Facial Reconstruction. Thus, dissertations, theses, articles, book chapters and other activities are produced with the aim to improve knowledge, enable its application in forensic science and collaborate with community service[30]. Today, it is known that dissertations and theses are types of productions that act as key channels for the dissemination of knowledge because it usually contains information not found anywhere else and described in detail. So projects like OFLab are important to encourage research and study groups on forensic sciences, in particular FFR. However, the non-publication of these papers in journals can harm the spread of scientific knowledge, which drew attention to the little space occupied by the category "Article" in Table 1.

5. Conclusion

We conclude that Brazilian literature in the area of Forensic Facial Reconstruction has been growing but there is still a lack of research. The preparation of theses, dissertations and subsequent publication is valuable for the development of Forensic Sciences and Forensic Dentistry.

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