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| ORIGINAL

Analysis of smile photos posted on social networks as an alternative for human identification

Análise de fotos do sorriso postadas em redes sociais como alternativa para a identificação humana

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ABSTRACT

Photos of smiles posted on social media contain information on individuals' anatomical and oral morphological characteristics, which can be important for *ante* and post-mortem human identification, during confrontation for forensic purposes. **Objective**: The study aimed to evaluate the feasibility of using smile photographs on social networks as a source of information for human forensic identification. **Methods**: The study sample consisted of forty individuals, randomly divided into four equal groups, two groups in Instagram (IG®) and two groups in Facebook (FB®). Standardized oral photographs of the anterior teeth of the participants, from three different angles (post-mortem photos) were taken using a Nikon® EOS 550D camera. Photos of smiles posted in FB and IG by the participants were also collected (ante-mortem photos). The analysis were carried out by 4 forensic experts, 18 dental professors, and 21 dental students. They compared simulated ante and post-mortem photos, to identify the alleged victims. **Results**: The correct identification score ranged from 28.6% (students) to 100% (forensic experts). The most frequently reported dental characteristics used for the identification were morphology of the anterior teeth, zenith, and gingival recessions. There was no statistically significant association between the rate of correct identification and the degree of difficulty reported during the analysis (p= 0,068), whereas there was also no association between this index and or the duration of the analysis (p=0,884). **Conclusion**: Therefore, the photographs of the smile posted on social media proved to be a database of dental information, and with potential to assist in identification with dental forensic purposes.

Indexing terms: Forensic anthropology. Forensic dentistry. Smiling. Social networking.

RESUMO

Fotos de sorrisos postadas nas redes sociais contêm informações sobre as características anatômicas e morfológicas orais dos indivíduos, que podem ser importantes para a identificação humana ante e post-mortem, durante o confronto para fins forenses. ***Objetivo****: O estudo teve como objetivo avaliar a viabilidade do uso de fotografias de sorrisos em redes sociais como fonte de informação para identificação forense humana.* ***Métodos****: A amostra do estudo foi composta por quarenta indivíduos, divididos aleatoriamente em quatro grupos iguais, dois grupos no Instagram (IG®) e dois grupos no Facebook (FB®). Fotografias orais padronizadas dos dentes*

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anteriores dos participantes, de três ângulos diferentes (fotos post-mortem), foram tiradas com uma câmera Nikon® EOS 550D. Também foram coletadas fotos de sorrisos postados no FB e IG pelos participantes (fotos ante-mortem). As análises foram realizadas por 4 peritos forenses, 18 professores de odontologia e 21 alunos de odontologia. Eles compararam fotos simuladas ante e post-mortem, para identificar as supostas vítimas. Resultados: A pontuação correta de identificação variou de 28,6% (alunos) a 100% (especialistas forenses). As características dentais mais frequentemente relatadas e utilizadas para a identificação foram morfologia dos dentes anteriores, zênite e recessões gengivais. Não houve associação estatisticamente significativa entre a taxa de identificação correta e o grau de dificuldade relatado durante a análise (p = 0,068), assim como não houve associação entre esse índice e/ou a duração da análise (p = 0,884). Conclusão: Portanto, as fotografias do sorriso postadas nas redes sociais mostraram-se um banco de dados de informações odontológicas, e com potencial para auxiliar na identificação para fins odontológicos forenses.

Termos de indexação: *Antropologia forense. Odontologia legal. Sorriso. Rede social.*

INTRODUCTION

Forensic Science works with human identification, whether for legal or humanitarian reasons, and it may be necessary even before the determination of an individual's cause of death. The identification process, including the investigation of homicide cases, or the one involving the identity of corpses for which no supporting documentation is available, is rigorous and follows well-known methods of unquestionable efficiency [1].

Interpol's Disaster Victim Identification Guide classifies identification methods into primary, such as papilloscopy, comparative dental analysis, DNA testing, and the unique serial numbers of medical implants; and secondary, such as personal description, medical findings, tattoos, or possessions and items of clothing found with the body [2]. The primary methods use techniques conducted with high technical-scientific rigor, allowing a reliable and safe identification, when at least one of these methods is used, while secondary methods are only responsible for supporting or supplementing information [2]. The human dentition contains specific information/data to each individual, therefore, having a discriminatory role [3].

Human teeth tend to withstand natural decomposition and the environmental elements (physical and chemical damages), which normally degrade the other tissues of the human body, due to their chemical composition, biological, physical and structural properties, and the properties of restorative materials used in Dentistry. This gives teeth great value for the forensic practice of human identification [4,5].

The condition in which the individual's body is found may determine the methodology to be employed in its identification. The identification of charred, putrefied, or skeletonized corpses, through dental characteristics, is a comparative-type methodology, as it compares information obtained from ante-mortem documentation (AM) with data collected post-mortem (PM). This method is divided in three stages: examination of the corpse's dental arches, examination of dental documentation and forensic data comparison [6].

The forensic data comparison is the moment when all information obtained about the individual (AM and PM) is compared in the search for coincidences. The comparative dental analysis has some advantages such as low-cost operating, quick analysis and interpretation of data and high reliability of results [7,8]. Those advantages are due to the individuality of every person and the unique set of features within their smile, such as: relationships of symmetry, dental positioning, gingival contours, inter-dental contacts, incisal edges, teeth proportions and also, its particularities. All those features are frequently found in the dental documentation produced still in the individual's life [9].

For this data comparison to take place, the forensic experts need to obtain from the victim's family all formal dental documentation that the individual has produced in life, which contains their identification features [10]. Dental records (physical or digital), medical records, plaster models, radiographs and intra or extraoral photographs are the most used formal dental documentation to support the forensic data comparison - those are examples of AM documents [10]. These documents must contain details of the procedures performed on the patient and must be accurate and legible.

Extraoral photographs can play an important role in identification. Regarded that they are good quality and clearly show the teeth, it is possible to compare photographs taken before and after the individual's death [11]. Extraoral photographs, or the ones that show the smile, are currently widely used by individuals on social media to record different

moments of their daily lives. Therefore, our hypothesis is that photos published on social networks such as Facebook and Instagram, due to their easy access and intense expansion across all social classes, may have identification potential.

Thus, this study aimed to evaluate the feasibility of using smile photographs obtained from social networks as a source of information for forensic human identification.

METHODS

The project that originated the study was approved by the Research Ethics Committee at UFPI under the number 1,848,126. This study also complies with the ethical principles contained in specific Brazilian legislation. The individuals who participated in the study were junior students of the Undergraduate Course in Dentistry at UFPI, participating as simulated victims; and the examiners included forensic experts who work at the Institute of Legal Medicine Gerardo Vasconcelos (state of Piauí), professors of the Undergraduate Course in Dentistry at UFPI and senior dental students from the last term at UFPI. Both, participants and examiners, were explained about the study's methodology and that examiners would need to access the photos published by the participants on their social media would. Examiners and participants signed the Free and Informed Consent Term.

The study's method consisted of producing standardized extraoral photographs in three positions of the participants' teeth and asking examiners to try to identify the participants, comparing their extraoral photos with the smile photographs that the individuals had posted on social media, Facebook or Instagram.

Sample characteristics

Forty students regularly enrolled in Undergraduate Dentistry course at the Federal University of Piauí were conveniently selected to compose the sample based on the students' and researchers' schedules. The 40 students were extracted from a known universe of 108 students, equally divided into three classes of 36 students each, therefore, representing 37,03% of this universe.

The selected students were enrolled in classes from the 1st to the 3rd term, therefore they have not had yet started the clinical activities of the course. That was important to avoid direct visual contact with the study examiners (professors), thus avoiding any bias towards identification.

The examiners consisted of: 'GEx1' group - 21 junior students (87,5% of the 24 junior students at the time of the study) in the last term of the Undergraduate Course; 'GEx2' group - 18 professors (45% of the 40 of professors at the time of the study) at the Undergraduate Course in Dentistry at UFPI; and GEx3' group - four forensic experts (66,6% of the six professionals at the Institute of Legal Medicine Gerardo Vasconcelos (state of Piauí).

Sample selection criteria

A clinical examination of the students' dental arches was performed for their selection and to ensure homogeneity of the selected sample regarding the characteristics that could be used as identification. To ensure the homogeneity of the sample, the following inclusion and ineligibility criteria were adopted: inclusion criteria - to have an account on Facebook or Instagram, the social media photos should allow visualization of the anterior teeth within the smile display area; ineligibility criteria - individuals whose social media photos did not show the incisal edges of the maxillary anterior teeth, presence of orthodontic appliance, individuals with patent dental abnormalities, such as: missing anterior teeth, conoid teeth, use of artifacts such as piercings, dental prostheses, darkened teeth or other distinctive characteristics. However, the volunteers had individual dental features that might or might not be common to each other.

The examiners were personally invited and those who showed interest in the study were included.

Study steps and group randomization

After the analysis of the forty volunteers' social networks profiles, they were randomly divided into groups; G1FB and G2FB were 2 groups of ten students each, totalizing twenty profiles, consisting of participants with Facebook profile; G1IG and G2IG were 2 groups of ten participants with Instagram profiles.

Subsequently, a Nikon® EOS 550D 18-megapixel camera was used to take extraoral photographs of the anterior teeth of all participants. The photos were taken from three angles using soft tissue retractors to ensure that as many dental features as possible were visible.

Figure 1 shows the extraoral photographs of the anterior teeth of four simulated victims - right side, frontal, and left side perspective, respectively. The image shows the photographs that were analyzed by the study examiners during the simulated forensic data comparison. It is possible to observe all the anatomical details and dental particularities of each one of the volunteers.

Figure 1. Extraoral photographs of the anterior teeth of the four simulated victims that were later compared with the photographs of the social networks.

Afterwards, private accounts for the study were created on Facebook (to analyze the photos of volunteers from the G1FB and G2FB groups) and Instagram (to analyze the photos of the volunteers from the G1IG and G2IG groups), so that only the examiners had access to the volunteers' photos, after receiving the login data via e-mail.

In each group, one student was raffled by the researcher to represent the simulated victim. Then, the examiners should analyze his/her PM photo. Subsequently, the study examiners simultaneously accessed the AM photos, using a smartphone or tablet, and the PM photos, using a computer, trying to establish his/her identification. For this step, a self-applicable questionnaire was developed and hosted online, using the Google Forms ® platform, accessed by the examiners through a link sent via e-mail.

The questionnaire contained the PM photos to be compared simultaneously with the 10 possible AM social media profiles. The examiner should also tick a box with : 1) the social media to which the analyzed photos belonged to; 2) the criteria they used to identify the victim, using as justification the smile peculiarities of the victim; 3) the time spent to perform the analysis (up to 1 minute, up to 5 minutes, up to 10 minutes, more than 10 minutes); and 4) the

difficulty level, on a Lickert-type scale, from 1 to 5 (where 1 was 'easy', 3 to 'medium' and 5 to 'difficult') to make the identification. There was always one possible correct identification.

Figure 2 shows the simulated forensic comparison process the study examiners carried out.

Figure 2. Exemplification of the forensic data comparison carried out by the examiners.

Statistical analysis

The Statistical Package for Social Science - SPSS, IBM Corp. ®, version 26.0.0 was used as a tool for data analysis. To analyze the data of the anatomical and morphological features mentioned by the examiners during the identification process, descriptive statistics were applied. Fisher's exact test was applied to compare the performance of the evaluators groups to identify to whom the extraoral photographs belonged to. For the analysis of the association between correct identification and the level of difficulty and duration of the identification process, Pearson's chi-square test was applied. All analyzes were performed considering the 5% significance level ($p<0.05$).

RESULTS

Table 1 shows the rate of correct identification for each simulated victim by group of examiners.

Table 1. Index of correct identification by group of examiners for each simulated victim.

	GEx1 (%)	GEx2 (%)	GEx3 (%)	Average IIC**%	p*
G1FB	6 (**28.6**)	8 (44.4)	4 (**100**)	57.6	
G2FB	16 (78.6)	16 (**88.9**)	3 (75)	80.8	
G1IG	12 (58.4)	10 (55.6)	2 (50)	54.6	0.708
G2IG	11 (52.4)	7 (**38.9**)	2 (50)	47.1	
Average IIC%**	54.5	57	68.8	-	

Note: *Fisher's exact test. **IIC - Index of Correct Identification.

Except for victim G2IG, whose average correct identification rate was 47.1%, all other group of examiners obtained higher than 50% of correct identification rate.

The group of examiners GEx3 reached the highest average rate of correct identification and was the only group that correctly identified one victim in 100% of the cases: the simulated victim of the G1FB group. The simulated victim in the G2FB group had the highest average correct identification rate, especially by the GEx2 group. For the simulated victim in the G1IG group, the correct identification rate was the most constant, ranging between 50 and 58.4%.

GEx1 and GEx2 groups had the lowest correct identification rates, for the groups G1FB and G2IG, respectively. The simulated victim in G2IG had the lowest average correct identification rate. However, there was no statistically significant association between the correct identifications rates by the examiners and the simulated victim (p = 0,708).

Table 2 shows the distribution of the oral features of the simulated victims that the examiners used to base their identification upon.

The morphology of the anterior teeth (upper left canine to the upper right canine) alone or combined with another feature, was the most cited feature. The gingival architecture was the second most mentioned feature and included details such as the zenith position and the presence of gingival recessions. The teeth alignment was the third most mentioned by the examiners, and included rotations, inclinations, diastemas, crowding and the incisal border of the anterior teeth. Characteristics such as wear surfaces (on one tooth or group of teeth) and tooth color were the least frequently mentioned features.

Table 2. Most cited oral features by group of examiners for each simulated victim.

Features	G1FB			G2FB			G1IG			G2IG			TOTAL
	GEx1	GEx2	GEx3	GEx1	GEx2	GEx3	GEx1	GEx2	GEx3	GEx1	GEx2	GEx3	
Tooth color	1	1	1	1	-	-	3	1	-	1	1	-	8 (3.6%)
Attrition surfaces	-	-	-	7	2	-	-	-	-	2	4	-	13 (5.9%)
Teeth positioning	4	2	1	1	4	2	1	3	2	3	1	2	26 (11.6%)
Anterior teeth morphology	19	13	3	16	14	3	21	18	4	21	14	4	150 (66.9%)
Zenith and gingival recessions	12	6	1	2	-	2	1	-	1	1	1	-	27 (12%)

Table 3 shows the association between chosen dental or oral feature and the type of examiner response (correct or wrong) when they filled out the form.

It is observed that a high number of examiners' responses used the morphology of the teeth to justify their choice, associating this criterion with one justification or more. There was no statistically significant association between correct identification indexes and the victim's feature reported by the examiners (p = 0.245), not even when the examiner

reported having used more than one victim's feature as an identification parameter (one or more than one oral feature - p = 0.105).

Table 3. Combinations of justifications and number of correct answers in the examiners' responses.

Parameter		Correct identification		p*
		No	Yes	
Justification	None	4	12	0.245
	Morphology	36	52	
	Position	0	1	
	Attrition surface	2	2	
	Morphology and one justification	25	27	
	Morphology and other justifications	7	3	
	Gingiva and teeth color	1	0	
	TOTAL	75	97	
Number of justification combinations	No justification	4	12	0.105
	1 justification	38	55	
	More than 1 justification	33	30	
	TOTAL	75	97	

Note: *Pearson chi-square - SPSS, 2021.

Table 4 shows the association between the type of identification made by the examiners and the difficulty level estimated by them and the duration of the evaluation. Most examiners managed to correctly identify the victims, although they also classified the identification process as difficult. Most of those examiners who made correct or incorrect identification, did so within 5 minutes.

There was no statistically significant association between the number of correct identifications and the difficulty level (p = 0,068), nor between the number of correct identifications and the evaluation time (p = 0,884) reported by the evaluators.

Table 4. Association between the type of identification produced by the examiners and their difficulty level or evaluation time.

Identification	Difficulty level				Evaluation time				
	Easy	Medium	Difficult	N (%)	Up to 1 minute	Up to 5 minutes	Up to 10 minutes	More than 10 minutes	N (%)
Correct idenfication	20	26	51	97 (56.4)	12	56	17	12	97 (56.4)
Incorrect identification	8	15	52	75 (44.6)	9	47	10	9	75 (44.6)
N (%)	28 (16.2)	41 (23.8)	103 (59.9)	172	21 (12.2)	103 (59.9)	27 (15.7)	21 (12.20	172
p*	0.068				0.884				

Note: *Pearson chi-square - SPSS, 2021.

DISCUSSION

There was no statistically significant association between the frequency of correct identifications by the different groups of examiners and the groups of simulated victims on both social networks (table 1). This fact can be explained

by the homogeneity of the sample regarding its dental characteristics that supported the assessment and identification, as it did not allow a certain group of examiners to reach a higher frequency of correct identification in a given victim. Therefore, the selection of individuals in the sample can be validated, a crucial step to evaluate the proposed method. Both social networks provided similar conditions for identifying the photographs.

Social networks can be seen as a source of search for photos that contain particularities of the smile. In 2020, there was an increase of 10% in the number of new accounts, bringing the world total number of social networks users to 3.96 billion accounts, this number corresponds to more than half of the world's population, which are connected and use social networks such as Facebook and Instagram [12].

In this study, the social networks served as an easy-access and online database, available for the storage and sharing of photographs, in which it is possible to search for dental particularities in the photos that the individual produced in life. Due to its objective nature, those records can potentially be used as an identification parameter.

Another advantage of using social networks is the frequency that the photos are updated by its users. Brazil is the 3rd country in the world that spends the most time on social networks, with a daily average of 3 hours and 31 minutes of use, much above the world average of 2 hours and 24 minutes. Regarding posts, the daily average is 1.7 posts in the main feed of social networks and 13.1 stories per month. This means that, daily, millions of users post photographs that can display the smile clearly, and by doing so, recent dental treatments on anterior teeth (e.g., veneers and tooth whitening) can be recorded quickly and with quality, leading to greater chances of correct identification [12].

The morphology of the anterior teeth was the most cited feature used by the examiners to identify the victims. This fact is explained by the high perception of the human eye for metric details and proportions between the upper anterior teeth, more specifically, the central and lateral incisors and the canines. Together, these teeth compose a unique and specific set, which associated with the dental peculiarities of everyone, such as: dental shape and position) [13], acquired characteristics (fractures, pigmentations, attrition surfaces and dental interventions) [14] and inherent smile variables (anterior smile line, smile arc, upper lip curvature, most posterior teeth displayed) [15], provide individuality to one's smile.

The gingival architecture also played an important role in the identification process. Gingival zeniths and recessions were the second oral feature most cited by the examiners, together with the justification of the morphology of the anterior teeth. In fact, gingival zenith asymmetries have an impact on the aesthetics of the smile, and alterations greater than 1 mm are visible to the human eye, drawing attention to the smile [16].

Although the gingival architecture was frequently cited by the examiners of this study, it is worth mentioning that, for purposes of forensic identification, the gingival contours would not be a reliable feature because soft tissues face degradation during the first hours after the individual's death. In complex cases of human identification, gingival architecture analysis may not be suitable, and the identification should rely on the multidisciplinary approach established by Interpol (forensic odontology, forensic anthropology, and molecular biology (DNA studies) [2]. Therefore, the use of gingival contour may be seen as a limitation of the technique here described.

Teeth color was the least mentioned feature by the examiners, probably because that the sample consisted entirely of young adults (in the second decade of life), a period of life in which great color changes in the dental tissues are difficult to occur. This fact was verified during the clinical examination that preceded the extraoral photographs of the volunteers' arches. The use of image filters to edit these photos before posting can also explain this result. By seeking out the closest color to white, making the smile look more pleasant, the edition ends up changing the actual color of the teeth initially registered in the photos. Choosing only young participants may be considered as a limitation of the technique.

In real-life situations, it is not possible to control this factor, as victims may have characteristics that a well-trained eye (forensic experts, for example) would easily and quickly identify, for example, the presence of dental fractures or dental restorations, absence of teeth, or anomalies in the shape or color of the teeth. All these factors were controlled in this study to test the power/sensitivity of the method and such factors would make the identification extremely easy.

However, techniques for analyzing photographs of the smile in imaging software can be used in this process, adding greater technical-scientific rigor, and making the process more objective and reliable [17]. The literature highlights three techniques for analyses in photographs: direct morphological analysis, image overlap and comparison of smile lines [18].

The technique of overlap AM and PM images, consists in superimposing the PM image onto the AM image to copy the positioning and distance in which the AM image was acquired; then the opacity of the PM image is gradually decreased, in the search for similarities [18].

The smile line comparison technique recommends that a line should be drawn to copy the alignment of the incisal edges of the anterior teeth (left canine to right canine) from the photograph; this will result in an AM matrix. The process should be repeated for the PM photo, and then both matrices should be superimposed to look for similarities. These methodologies could have been applied to the technique suggested by our study, if necessary [19,20].

In our study, the morphology of the anterior teeth was the most cited justification for the examiners to justify their choices. In a similar study proposed by Silva [21], morphology was also highly cited as an identifying characteristic, playing an important role on the simulated forensic identification process. Unlike the techniques described above, the direct morphological analysis does not require use of specific softwares and has easier applicability, allowing even undergraduate students to achieve success and positive identification, similar to what was seen in our results [21].

Some factors may explain the low rates of correct identification of certain groups in our study. The fact that evaluators had to necessarily choose one victim in each group, combined with the fact that they only had a single opportunity to carry out this identification, situations that do not happen in the human identification practice can be considered a limitation of the method. However, some groups of evaluators reached a rate of correct answers above 75% (table 1).

In Forensic Dentistry, the data produced about a corpse to be identified must be carried out by a team of two experts, to ensure the quality of the data and reduce risk of misidentification, as recommended by the Interpol Disaster Victims Identification Guide [2]. Thus, it is likely that, when faced with the uncertainty of the correct profile and the obligation to carry out an identification, the evaluators of this study randomly chose one of the nine victims.

Furthermore, smile photo analysis has its requirements since it is used as an alternative method of identification. It would be important for the photographs to comply with some standardization criteria for them to be used, in addition to the primary identification techniques established by Interpol [2].

When using photographs as an identification tool should be taken into consideration as limitations such as: the difficulty of standardization of the photographs, that can generate variations in the positioning of the arch and smile amplitude, which would make it difficult to visualize some dental details or particularities; how long before the incident it was taken due to changes and/or interventions (dental treatments) in the teeth in the meantime; the quality and/or low resolution of the image, the quality of the camera that will produce the photograph, the environment lighting in which the photo has been taken and the spatial orientation of the individual in relation to the camera [11,22,23].

A limitation inherent to the technique described in our study concerns the quality of photos of volunteers posted in social networks. It is known that the algorithms that manage the upload of photos from users to social network servers are programmed to automatically reduce the resolution of files, so that they take up the least amount of memory possible, allowing the greatest possible storage of data. This can interfere with identification by reducing the chance of correct identification if there is a need to zoom in the image.

Ideally, when the individual has its identity document issued by the government, a simple and standard photographic record of the dental arches could be made, similarly to what is done with the fingerprints registration. This simple initiative would create a valuable data base with countless potential purposes. A dental forensic expert or a properly trained technician would be able to record or even scan the population's dental arches, creating its own national database, to be periodically updated. Those technologies are currently available for dental use.

Most evaluators (59.9%) graded the identification process as "difficult" (table 4). In fact, cases reported in the literature in which only smile photographs were able to establish the identity of bodies are rare. Thus, it is necessary to

associate this methodology with the primary identification techniques, making the identification process less prone to error [2].

The homogeneity of the sample was a factor that probably had an impact on the greater difficulty level for the group of students (GEx1) and professors (GEx2). When evaluating simulated victims without any visible dental abnormality, the search for coincidences was primarily based on the morphology of the anterior teeth, the predominant feature cited as a key point in identification. Dental anomalies play an important role in human identification because they individualize a person's dentition, in other words, they possess discriminatory character [16]. Therefore, if the study volunteers with visible dental abnormalities had been included in the sample, this would make confrontation a lot faster and easier for the examiners.

CONCLUSION

Smile photographs available on social networks are a potential alternative source of AM documentation, including those to be used successfully in the forensic data comparison. They could be incorporated as a complementary tool in the processes of human identification, as long as they are preceded by the primary techniques such as papilloscopy, DNA testing or conventional dental arch examinations.

Collaborators

WP Ferreira, data collection, data analysis, and manuscript writing. VA Lages, data collection, study conception and design, and manuscript writing. RR Prado Júnior, conception and design of the study, analysis and interpretation of data, and manuscript writing.

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