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FACULDADE DE ODONTOLOGIA DE PIRACICABA

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Dissertation presented to the Piracicaba Dentistry School of the University of Campinas in partial of the requirements for the degree of Master in Buco-Dental Biology, in Forensic Dentistry area.

Dissertação apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Mestra em Biologia Buco-Dental, na área de Odontologia Legal e Deontologia.

Orientador: Prof. Dr. Felippe Bevilacqua Prado
Coorientador: Prof. Dr. Eduardo Daruge Junior

Este exemplar corresponde à versão final da dissertação defendida pela aluna Bruna Carolina Santos Rondon e orientada pelo Prof. Dr. Felippe Bevilacqua Prado.

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Prof. Dr. FELIPPE BEVILACQUA PRADO

Prof. Dr. PAULO ROBERTO BOTACIN

Profa. Dra. ANA CLÁUDIA ROSSI

ABSTRACT

Rich in detail, the jaw is a bone that may be useful in determining the sex of the individual, because it features presents a high degree of sexual dimorphism. However, studies that correlate this trait with other individual characteristics have been little discussed, and because of this the aim of the study was to evaluate the influence of facial biotype and dental status in sexual dimorphism, by morphometric analysis of human jaw. 900 panoramic radiographs were evaluated. Facial biotype of the individuals had been previously determined by clinical exams and clinical records of the panoramic radiographs. For inclusion in the sample were selected panoramic radiographs with age group 11-91 years (±43.3 years). The measurements were made in specific software and adjusted according to the magnification of the panoramic imaging. Only one researcher performed the measurements. On both sides, the following measurements were performed: gonial angle, antegonial angle, antegonial depth, posterior curvature of the mandibular branch, depth of mandibular incisure. Differences between the right and left sides of the mandible, sex and facial biotype of the individual were subject to analysis of variance (ANOVA) to verify the sample groups difference. After we applied the Tukey-LSD test to describe the significant differences of the groups. The logistic regression test was performed showing a setting of appropriate model by Hosmer & Lemeshow test and Chi-square tests. The analysis of variance (ANOVA) showed no statistically significant differences between the sides of any measures, considering the other conditions (sex, dental condition and facial biotype). There were no statistically significant differences between the sexes and age groups. The results of regression showed that the gonial angle and age did not influence the sex determination by the model proposed, and, were not considered. The accurate prediction of the sex considering the targeted model in relation to the facial biotype is 63.7%. Have no influence of the dental status in the model, and the accuracy rate was higher in total dentate (71.3%). In conclusion, the mandibular change in gonial and antegonial regions occurs mainly according to dental status and sex.

Keywords: forensic odontology; panoramic radiograph; bone remodelation**.**

RESUMO

Rica em detalhes, a mandíbula é um osso que pode ser útil na determinação do sexo do indivíduo, pois características presentes nela apresentam alto grau de dimorfismo sexual. No entanto, estudos que correlacionam este traço com outras características individuais têm sido pouco discutidos, e por isso, o objetivo deste estudo foi avaliar a influência do biotipo facial e da condição dentária no dimorfismo sexual, por meio da análise morfométrica da mandíbula humana. Foram avaliadas 900 radiografias panorâmicas. O biotipo facial dos indivíduos já havia sido determinado previamente pelos registros obtidos nas radiografias panorâmicas. Para fazer parte da amostra, foram selecionadas radiografias de indivíduos com faixa etária entre 11-91 anos (±43.3 anos). As medições foram feitas em software específico e apenas um pesquisador realizou as medidas. Em ambos os lados foram realizadas as seguintes medidas: ângulo goníaco, incisura pré-goníaca, profundidade da incisura pré-goníaca, curvatura posterior do ramo mandibular e profundidade da incisura mandibular. As diferenças entre os lados direito e esquerdo da mandíbula, sexo e biotipo facial foram submetidos à análise de variância (ANOVA) para verificar diferenças nos grupos amostrais. Depois, foi aplicado o teste de Tukey- LSD para descrever as diferenças que foram significativas dos grupos. O teste de regressão logística também foi realizado, e a análise de variância (ANOVA) não mostrou diferenças estatisticamente significativas entre os lados de todas as medidas, considerando-se as demais condições (sexo, condição dental e biotipo facial). Não houve diferenças estatisticamente significantes entre o sexo e idade. Os resultados da regressão mostraram que o ângulo goníaco e idade não influenciaram na determinação do sexo pelo modelo proposto, e não foram considerados. A predição do sexo, considerando o modelo em estudo em relação ao biótipo facial é de 63,7%. Não houve influência da condição dentária no modelo, e a taxa de precisão foi maior nos dentados totais (71,3 %). Em conclusão, as alterações mandibulares nas regiões do ângulo goníaco e incisura pré-goníaca ocorrem principalmente de acordo com a condição dentária e sexo.

Palavras-chave: Odontologia legal; radiografia panorâmica; remodelação óssea.

SUMÁRIO

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"Uma perícia bem feita é capaz de fazer dos vestígios deixados na cena do crime a única testemunha capaz de expressar a verdade absoluta e, portanto, a justiça que sempre se busca"

(Autor desconhecido)

INTRODUÇÃO

O conhecimento de diversas técnicas para identificação humana é imprescindível no cenário da sociedade moderna. Antropólogos forenses de todo mundo enfrentam uma difícil batalha contra o comportamento criminal, que inclui desmembramento de corpos de vítimas de crimes e assassinatos que desafiam os policiais e cientistas na elucidação dos fatos. Uma possível melhora na luta contra as tendências da criminalidade é a maximização das evidências disponíveis, que podem ser encontrados a partir de materiais esqueléticos incompletos e muitas vezes fragmentados. A este respeito, a determinação do sexo continua a ser um aspecto crítico da identificação humana, uma vez que reduz o número de combinações possíveis a 50%, ao mesmo tempo em que serve como conjunto de dados de referência para os procedimentos de identificação (Dayal, 2008).

A manifestação dos traços anatômicos definitivos não ocorre antes do desenvolvimento das características sexuais secundárias, que aparecem na puberdade e se completam primeiro nas mulheres, deixando-as com aparência mais delicada. O crânio masculino, por sua vez, exibe maior robustez e áreas de fixação muscular (Hsiao, 2010), características bem marcantes quando da análise de um crânio.

No entanto, existem muitas variações entre os traços considerados extremamente masculinos e os notadamente femininos, fato que instiga a pesquisa de outros meios de promover a distinção sexual, por meio de outros ossos, por exemplo.

Sendo assim, uma das formas de se estudar o dimorfismo sexual é pela mandíbula; e Hu *et al.* (2006) afirmaram ser este o osso mais resistente e dimórfico do crânio, e importante para a diferenciação entre os sexos. Isso se dá pela presença de uma densa camada de osso compacto, que a deixa estável e melhor preservada que os demais ossos (Saini, 2011a). Além disso, é a última estrutura a cessar o crescimento, sendo sensível ao desenvolvimento da puberdade (Saini, 2011b).

A determinação do sexo pela mandíbula suscita vários questionamentos, dentre eles quais são os pontos craniométricos fidedignos para este fim, e os autores têm elaborado

diversos métodos para análise desse osso. Em 2002, pesquisadores (Kemkes-Grottenthaler *et al.*) realizaram exame minucioso e qualitativo da mandíbula (n=233), e concluíram que a idade e a perda dentária do indivíduo reduziam seriamente a eficácia dos traços analisados. Além disso, declararam que os indicadores eram propensos a discrepâncias intra e inter-observadores, e, embora ambos possuissem mérito como indicadores de sexo, apresentavam variáveis que não poderiam ser usadas para todas as amostras.

Hu *et al.* 2006 analisaram as características morfológicas da mandíbula de 102 Coreanos, de ambos os sexos. Das 13 características não métricas analisadas, a que permitiu distinção dos sexos de forma segura foi o contorno da borda inferior da mandíbula: bem acentuada no sexo masculino (68.1%) enquanto que a maioria das femininas (84.6%) exibiu uma mandíbula reta.

Franklin *et al.* 2008 produziram uma série de medidas métricas em 225 mandíbulas de indivíduos Sul-africanos negros, e nove medidas lineares foram analisadas por estatística simples e análise de função discriminante, tendo como resultado que todas as medidas eram sexualmente dimórficas, e a exatidão ficava entre 63.6% e 84%, dependendo da variável considerada. Com isso, os autores puderam concluir que a mandíbula é um osso útil para a determinação do sexo na população estudada.

Em trabalhos recentes, vê-se o cuidado dos pesquisadores em verificar se outros fatores têm ação no formato e desenvolvimento da mandíbula, em especial o ângulo mandibular. Assim, Oettlé *et al.* 2009 avaliaram a influência da idade, sexo, etnia e dentição no ângulo mandibular em uma amostra da população Sul-Africana e encontraram que a perda dos dentes molares, especialmente se completa ou desigual, tem um efeito considerável no ângulo, tornando-o mais obtuso.

Além do estudo direto, por meio da análise do osso em si, ao longo dos anos os pesquisadores desenvolveram métodos de avaliação indireta, pelos exames imageológicos. Isso facilita o trabalho e permite que um maior número de espécimes sejam comparados.

Desta forma, Xie *et al.* 1996 afirmaram, depois do estudo de 365 panorâmicas de pessoas com média de idade de 27 anos, que os idosos tinham um maior ângulo goníaco que os indivíduos mais jovens. O ângulo mandibular também está relacionado com a pouca altura do remanescente ósseo mandibular e com a fina cortical vista em mulheres edêntulas.

Já Dutra *et al.* 2004, se concentraram nas alterações ocorridas na região da incisura pré-goníaca, e observaram que há um padrão de reabsorção deste local em mandíbulas desdentadas totais, e sua morfologia é influenciada pelo sexo e condição dentária. Em 2005 continuaram concentrados nesta região e puderam constatar que mulheres edêntulas e com alguma alteração óssea (osteoporose e osteopenia, por exemplo) possuíam alterações na incisura pré-goníaca e na área total da mandíbula quando esses caracteres anatômicos foram analisados em radiografias panorâmicas, nos dois estudos mencionados.

Com base na literatura, verificou-se falta de estudos que relacionavam essas estruturas com as variáveis citadas, e, portanto o presente trabalho objetiva correlacionar as dimensões mandibulares com o biotipo facial, condição dental e idade dos indivíduos para determinação do sexo.

CAPÍTULO 1: Morphometric evaluation of human mandible in panoramic radiograph: influence of facial biotype and dental condition in sexual dimorphism*

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ABSTRACT

The aim of this study was evaluated the influence of facial biotype and dental condition in sexual dimorphism by morphometric analysis of human mandible in panoramic radiograph. 900 panoramic radiographs were evaluated. Facial biotype of the individuals had been previously determined by clinical exams and clinical records of the panoramic radiographs. For inclusion in the sample were selected panoramic radiographs of individuals fully permanent dentition and with age group 11-91 years (±43.3 years). The measurements were made in specific software and adjusted according to the magnification of the panoramic imaging. Only one researcher performed the measurements. On both sides, the following measurements were performed: gonial angle, antegonial angle, antegonial depth, posterior curvature of the mandibular branch, depth of mandibular incisure. Differences between the right and left sides of the mandible, sex and facial biotype

of the individual were subject to analysis of variance (ANOVA) to verify the sample groups difference. After we applied the Tukey-LSD test to describe the significant differences of the groups. The logistic regression test was performed showing a setting of appropriate model by Hosmer & Lemeshow test and Chi-square tests. The analysis of variance (ANOVA) showed no statistically significant differences between the sides of any measures, considering the other conditions (sex, dental condition and facial biotype). There were no statistically significant differences between the sexes and age groups. The results of regression showed that the gonial angle and age did not influence the sex determination by the model proposed, and, were not considered. The accurate prediction of the sex considering the targeted model in relation to the facial biotype is 63.7%. Have no influence of the dental status in the model, and the accuracy rate was higher in total dentate (71.3%). In conclusion, a continuous bone remodeling occurs in gonial and antegonial regions mainly according to dental status and sex.

Keywords: forensic odontology; panoramic radiograph; bony remodelation**.**

INTRODUCTION

One of the most important elements of forensic dentistry is the morphometric evaluation, especially the skeleton, Numerous studies have been conducted by teeth and skeletal structures of the human body, however most of these studies focuses on morphology, odontometry and bony variations, regarded specifically to the ethnic and gender (Robinson, 2003; Nasseh, 2002; Rai, 2003).

Dental identification is one of most common ways used to identify individuals. The *post-mortem* identification requires investigation of biometric data which are unique to the individual and are able to withstand severe *ante-mortem* conditions. Dental features remain as one of the most effective methods for *post-mortem* identification. Variations in these characteristics, such as angulation, morphology and/or degree of restoration, provide a satisfactory number of different characteristics compared with dental documentations

before and after death (Jacobs, 2004; Kuzmanovic, 2003; Steyn, 1997; Akarslan, 2003; Dharmar, 1997; Sakakura, 2004; Philips, 1992).

Howerver, in case of toothless invidual with facial biotype, whose mandible presented bone remodeling, the forensic dentist have only the mandibular morphology, anatomical variations and their dental records as a potential and reliable sources for indentifying (Ceylan, 1998; Steyn, 1998).

In these cases, the use of panoramic radiograph is considered in *post-mortem* identification, since it has the ability to shows anatomical landmarks of entire maxillomandibular region and allows for sex determination with 80 to 100% accuracy (Patil & Mody, 2005).

Studies that involve linear and angular morphometrics applied to dental radiographs are applicable for specific population groups due to differences in ethnic and environmental factors, such as time of tooth extraction, osteoporosis, feed behavior and use of dental prostheses, periodontal disease, age and facial biotype that can influence the expected results.

Thus, the aim of this study was evaluated the influence of facial biotype and dental condition in sexual dimorphism by morphometric analysis of human mandible in panoramic radiograph.

MATERIALS AND METHODS

This study was approved by the Committee for Ethics of Research of the State University of Campinas (Protocol: 094/2012 – Annex 2).

Sample

We evaluated 900 panoramic radiographs of the collection of the Anatomy area of the Piracicaba Dental School – State University of Campinas (UNICAMP), Piracicaba-SP, Brazil. The sample was distributed according table 1.

Facial biotype of the individuals had been previously determined by clinical exams and clinical records of the panoramic radiographs.

Table 1. Distribution of the sample in groups.

Group	N (sex)	Dental condition	N (facial biotype)
1	150 (male)	Full dentate	50 (dolichofacial), 50 (mesofacial) and 50 (brachyfacial)
2	150 (male)	Partial dentate	50 (dolichofacial), 50 (mesofacial) and 50 (brachyfacial)
3	150 (male)	Edentulous	50 (dolichofacial), 50 (mesofacial) and 50 (brachyfacial)
4	150 (female)	Full dentate	50 (dolichofacial), 50 (mesofacial) and 50 (brachyfacial)
5	150 (female)	Partial dentate	50 (dolichofacial), 50 (mesofacial) and 50 (brachyfacial)
6	150 (female)	Edentulous	50 (dolichofacial), 50 (mesofacial) and 50 (brachyfacial)

Digital panoramic radiographs were obtained using an Orthopantomograph® OP100 D unit (Instrumentarium Corp.,Imaging Division, Tuusula, Finland), operating at 66 kVp/2.5mA and an exposure time of 17.6 s. 3D images were obtained using a Classic i-CAT CBCT unit (Imaging Sciences International, Inc., Hatfield, PA), operating at 120 kVp/8mA, with a 0.25mm voxel size and a field of view of 8 cm.

Criteria for Inclusion and Exclusion of radiographs in the sample

For inclusion in the sample were selected panoramic radiographs of individuals permanent dentition and with age group 11-91 years (±43.3 years). The radiographs were distributed in age groups as follows: 11-20 years: 143; 21-30 years: 210; 31-40 years: 123; 41-50 years: 123; 51-60 years: 91; 61-70 years: 117 years; 71-80 years: 105 years; 81-90 years: 33; 91-100 years: 1.

The evaluation of the dental status was performed as follows: the full dentate presented all upper and lower teeth (the third molar was not considered in the evaluation); the partial dentate presented absence of one or more teeth in both maxillaries (the third

molar was not considered in the evaluation); the edentulous presented absence of all teeth, in both maxillaries.

Panoramic radiographs with cut and/or distorted, with radiological evidence of intra-osseous pathologies, and/or with fractures with or without bone fixation plates were excluded from the study. However, there were no data about time of tooth loss and denture use, and because of this these factors could not be considered for inclusion / exclusion in the work.

Radiographic measurements

All the measurements were made using the software ImageLab2000® and obtained in millimeters (mm) and degrees (°). This computer software has several tools that were used in this study, such as linear and angular measurements. The measurements were adjusted according to the magnification of the panoramic imaging. Only one researcher performed the measurements.

On both sides, the following measurements were performed according to Dutra *et al.* (2004):

a) ***Gonial angle:*** tracing a line tangent to the lower border of the mandible and another line tangente to the distal border of the ramus on each side. The intersection of these lines formed the mandibular angle (Figure 1A).

b) ***Antegonial angle:*** tracing two lines parallel to the antegonial region that will intersect at the deepest point of the antegonial notch (Figure 1B).

c) ***Antegonial depth:*** the distance along a perpendicular line from the deepest point of the notch concavity to a tangent through the inferior border of the mandible (Figure 1C).

d) ***Posterior curvature of the mandibular branch***: line parallel to the posterior border of the mandibular branch; after the same region two parallel lines were drawn, and the deepest point where they intercept the angle formed which indicated the posterior curvature of the mandibular branch (Figure 2D).

e) ***Depth of mandibular incisure:*** was measured in two traces: one passing tangent to the condyle and the coronoid process and a perpendicular line extending from the deepest point of the notch to find another line already had drawn (Figure 2E).

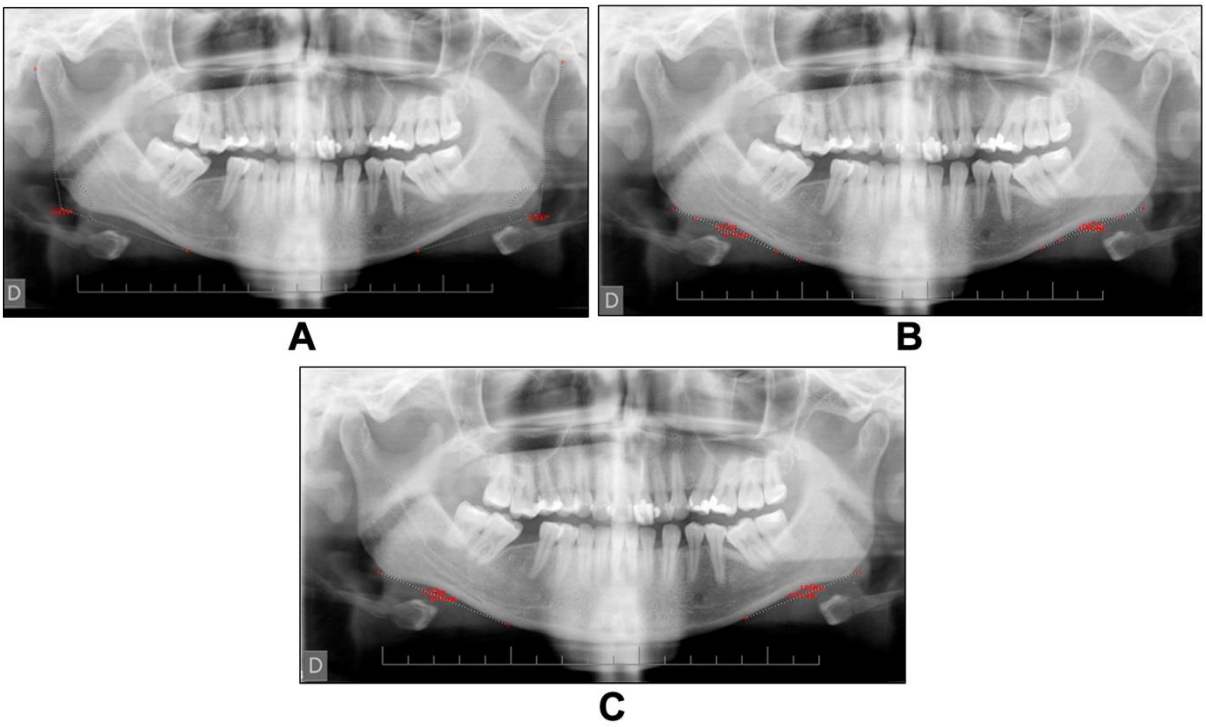

Figure 1. Measurements in panoramic radiograph according to Dutra *et al.* (2004). A) Gonial angle; B) Antegonial angle; C) Antegonial depth.

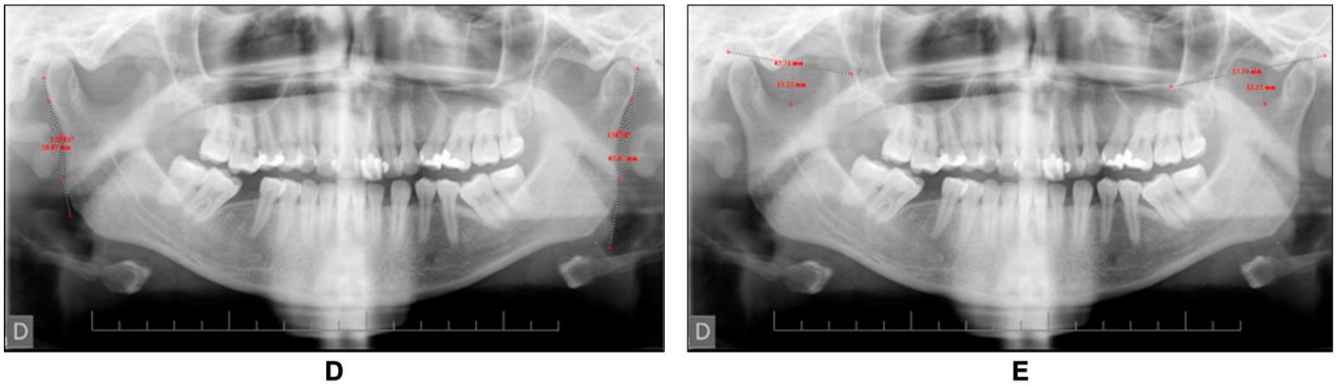

Figure 2. Measurements in panoramic radiograph according to Dutra *et al.* (2004). D) Posterior curve of the mandibular branch; E) Depth of mandibular incisure.

Reliability

Assessment of measurement reliability of replicate measurements of angles and distances was carried out using graphs and the concordance correlation coefficient (CCC). For the intraobserver reliability 20% of the sample was randomly selected and the angles and distances re-measured 3 times.

Statistical analysis

Data were analyzed using BioEstat software v. 5.0 (Ayres Company, Pará, Brazil). Differences between the right and left sides of the mandible, sex and facial biotype of the individual were subject to analysis of variance (ANOVA) to verify the sample groups difference. After we applied the Tukey-LSD test to describe the significant differences of the groups.

The logistic regression test was performed showing a setting of appropriate model by Hosmer & Lemeshow test and Chi-square tests.

RESULTS

The analysis of variance (ANOVA) showed no statistically significant differences between the sides of any measures, considering the other conditions (sex, dental condition and facial biotype). Thus, it was considered for the other calculations the average of the right and left sides.

There were no statistically significant differences between the sexes and age groups (Figure 3).

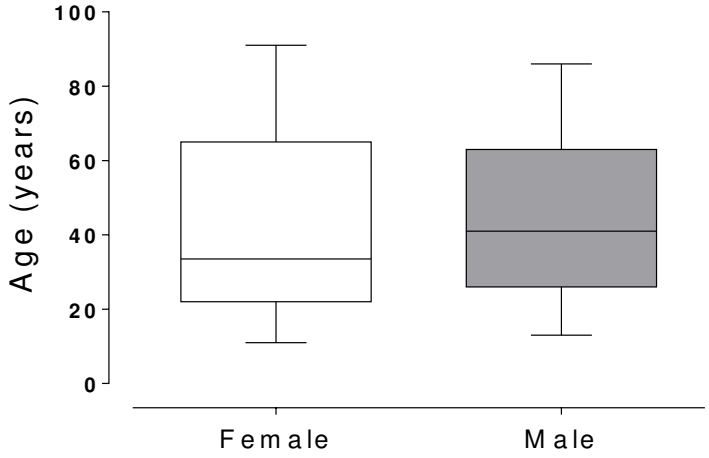

Figure 3. Sample distribution of ages between female (n = 450) and male (n = 450) sexes.

Age was higher in edentulous than in total or partial dentate individuals, and the total dentate had lower age than the other groups, regardless of sex and facial biotype (Figure 4). Age was considered as a cofactor in subsequent statistical analyzes.

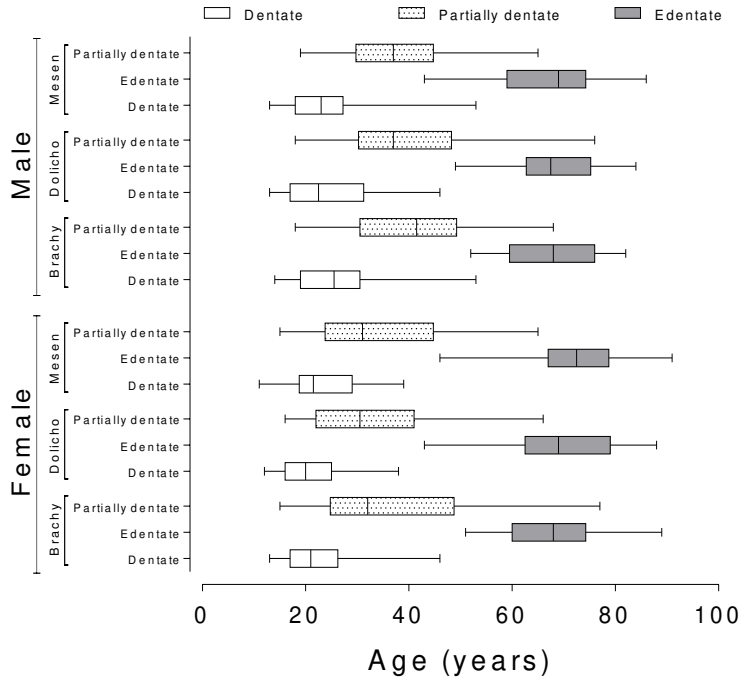

Figure 4. Distribution of ages in relation to other variables.

Gonial angle: In general, gonial angle was influenced by gender (p=0.0161), dental condition (p= 0.003) and facial biotype (p<0.001). Figure 5 shows the average (± standard deviation) of the gonial angle as a function of the variables studied. Females had smaller gonial angle than males (p=0.01589). Dentate showed smaller gonial angle than edentulous (p=0.0002) and partially dentate (p=0.0059), which had smaller gonial angle than edentulous (p= 0.0120). Dolichocephalic had greater gonial angle than brachycephalic (p=0.0056) and mesencephalic (p<0.0001), which did differ with brachycephalic ones (p=0.44).

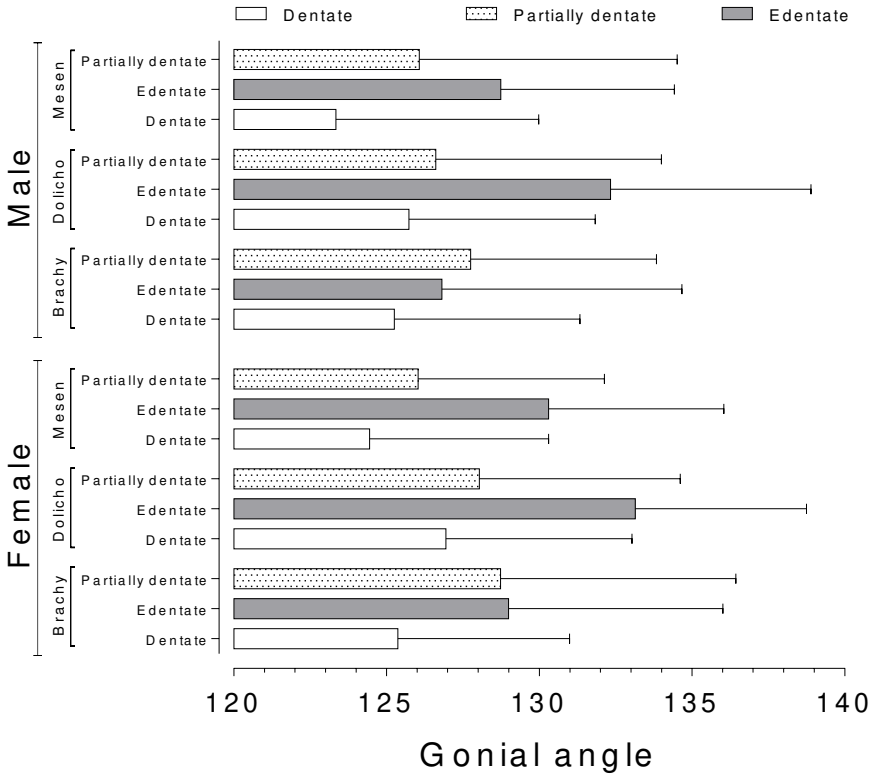

Figure 5. Values of the gonial angle in relation to the variables studied.

Antegonial angle: Only dental condition (p=0.00176) influenced the antegonial angle. In general, dentate presented greater antegonial angle than partially dentate (p=0.0238), and no differences with edentate (p=0.9604). Edentate did not show differences in comparison with the partially dentate (p=0.0729). Figure 6 shows the average (± standard deviation) of antegonial angle in function of the variables.

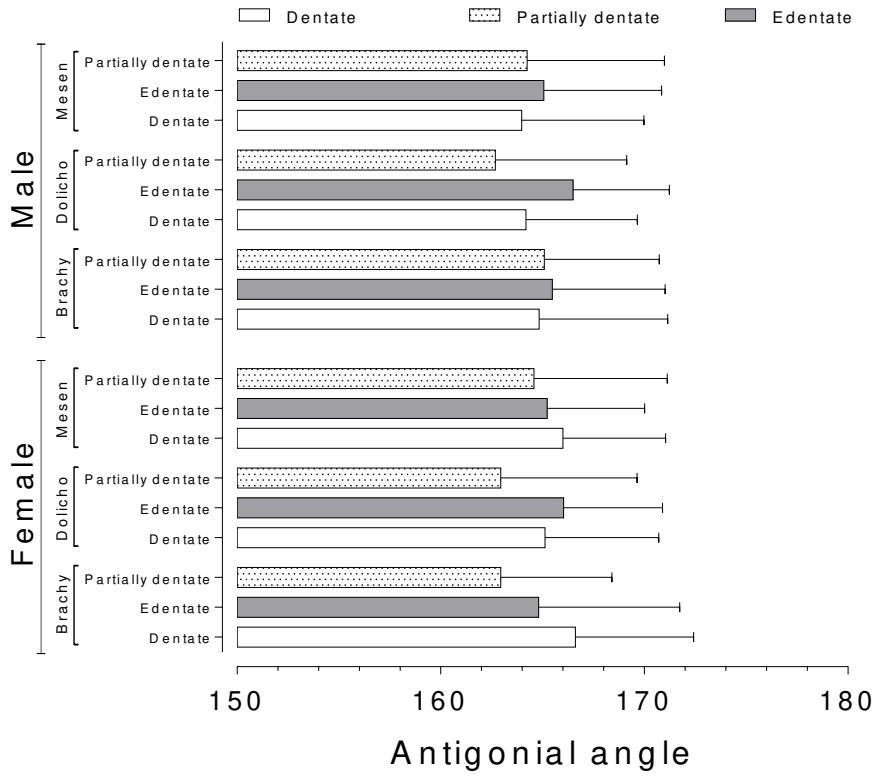

Figure 6. Values of antegonial angle in relation to the variables studied.

Antegonial depth: In general, males showed greater antegonial depth than females ($p<0.0001$). Dentate showed smaller antegonial depth than edentulous ($p= 0.01437$) and partially dentate ($p= 0.04855$), which did not differ from edentulous ($p= 0.13921$) as shown in Figure 7.

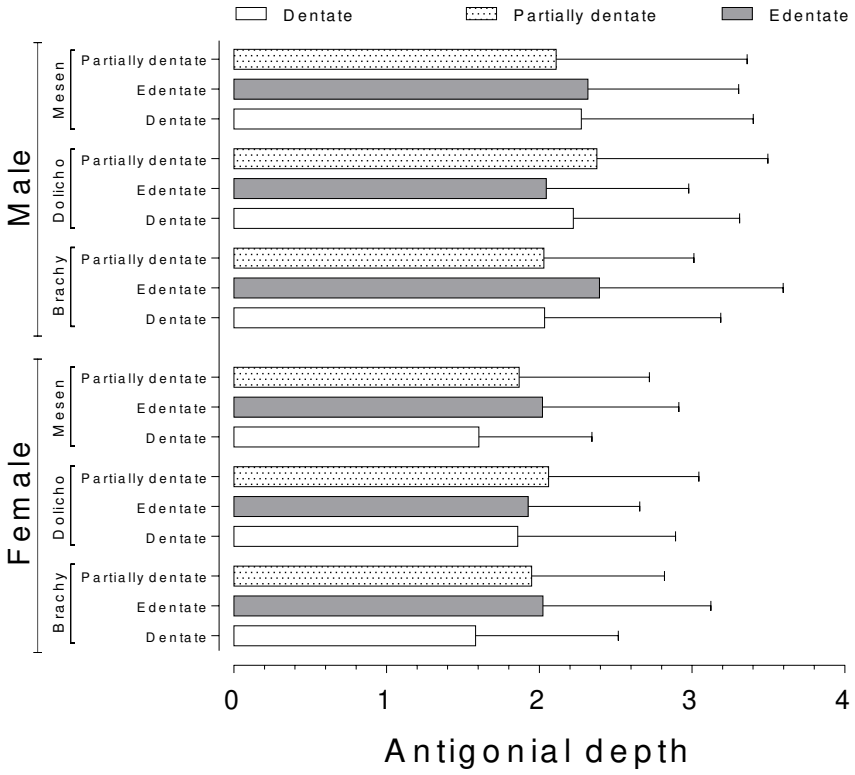

Figure 7. Values of antegonial depth in relation to the variables studied.

Posterior curvature of the mandibular branch: Males showed greater posterior curvature than female (p=0.0025). Edentate showed greater values than dentate (p=0.0026) and partially dentate (p=0.0001) with no statistically significant differences between dentate and partially dentate (p=0.99) (Figure 8).

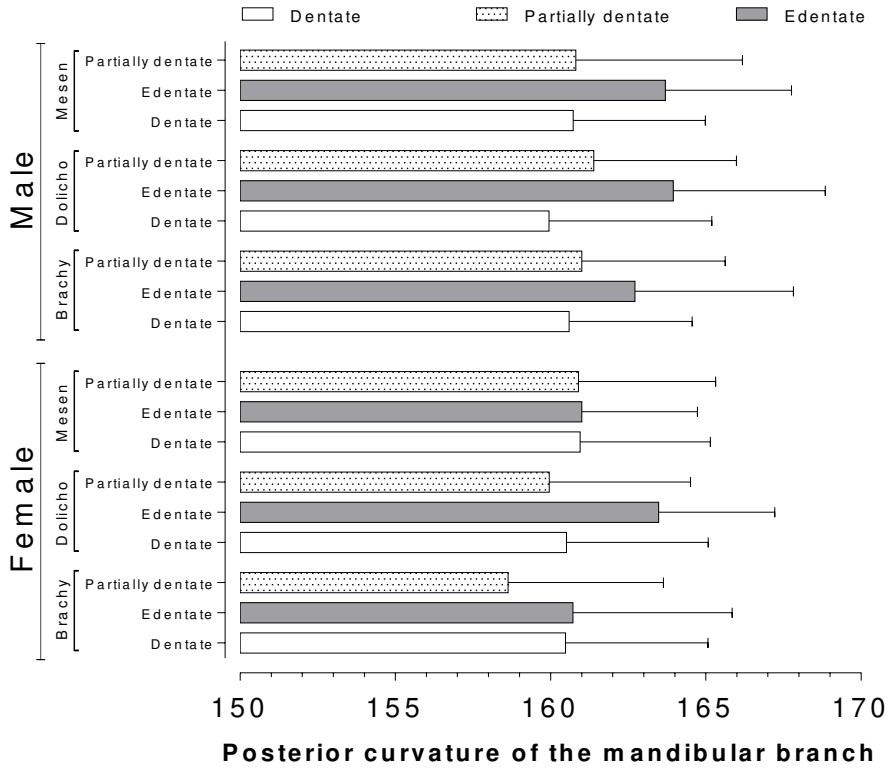

Figure 8. Values of posterior curvature of the mandibular branch in relation to the variables studied.

Depth of mandibular incisure: male presented greater depth of mandibular incisures than female ($p<0.00001$). Edentate had greater depth than dentate ($p<0.00001$) and partially dentate ($p<0.00001$), with no statistically significant differences between dentate and partially dentate ($p=0.00791$). The depth was greater in dolichocephalic than brachycephalic ($p=0.03154$), but no significant differences were observed between dolicho and mesencephalic ($p=0.21$) and between mesencephalic and brachycephalic ($p=0.69$) (Figure 9).

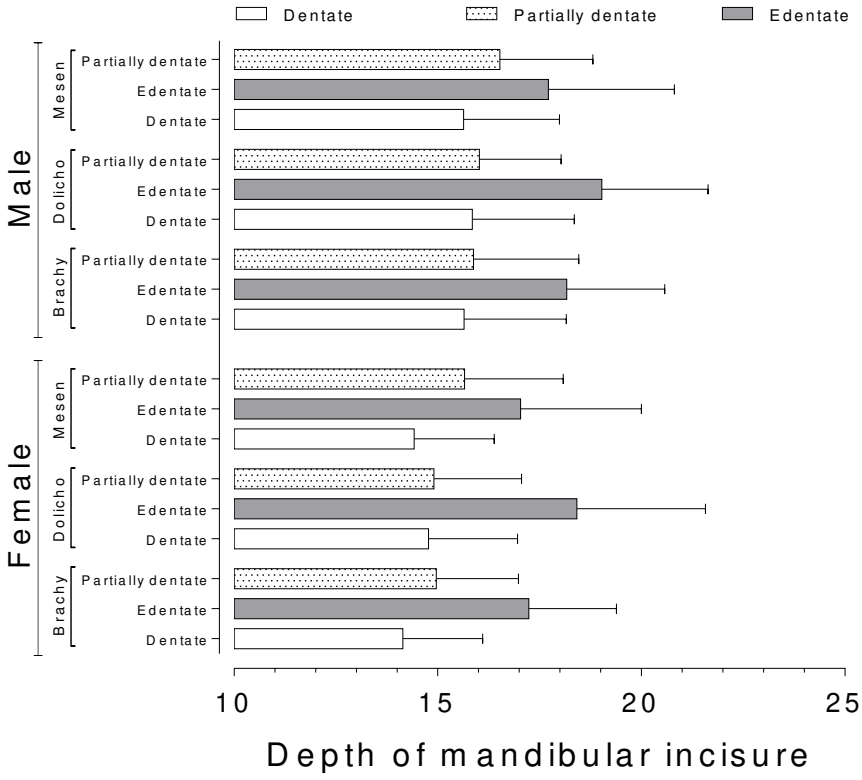

Figure 9**.** Values of depth of mandibular incisure in relation to the variables studied.

In Table 2 are listed the variables that had influence in each measurement performed.

Table 2. Variables with influence in measurements.

	Sex	Dental status	Facial biotype
Gonial angle	female	Full dentate	Dolichofacial
Antegonial angle	-	Full dentate	-
Antegonial depth	male	Full dentate	-
Posterior curvature of the mandibular branch	male	Edentulous	-
Depth of mandibular incisure	male	Edentulous	Dolichofacial

Using the variables, the logistic regression was constructed in order to predict the sex. For this analysis were not considered facial biotypes and dental conditions. The results of this regression can be seen in Table 3, where it is evident that the gonial angle and age did not influence the sex determination by the model proposed, and, therefore, were not considered.

Table 3. Logistic regression with variables.

Variable						**95% C.I.for EXP(B)**	
	B	**S.E.**	**Wald**	**Sig. (p)**	**Exp(B)**	**Lower**	**Upper**
Gonial angle	-0.018	0.011	2.850	0.091	0.982	0.962	1.003
Antegonial angle	0.092	0.022	17.975	0.000	1.097	1.051	1.145
Antegonial depth	0.798	0.129	38.258	0.000	2.221	1.725	2.859
Posterior curvature of the mandibular branch	0.053	0.016	11.042	0.001	1.055	1.022	1.089
Depth of mandibular incisure	0.114	0.029	15.277	0.000	1.121	1.058	1.186
Age	-0.006	0.004	2.421	0.120	0.994	0.987	1.002
Constant	-24.730	4.672	28.022	0.000	0.000		

Thus, the logistict regression was determined:

Sex= -25,635 + (0,091 x antegonial angle) + (0,798 x depth of antegonial angle) + (0,046 x posterior curve of mandibular branch) + (0,093 x depth of mandibular incisure)

The proposed model was significantly better than the determination by chance (Chi-square= 79.25, p<0.0001), presenting an adequate model (Hosmer & Lemeshow, Chi-square= 2.072, p= 0.9790). Table 4 shows the correct sex prediction by the proposed model was 62.0%.

Table 4. Success percentage obtained by the proposed model.

Observed		Predictor		
		Sex		Correct Percentage
		Female	Male	
Sex	Female	286	164	63,6
	Male	178	272	60,4
% total				62,0

To observe the factors could influence the regression, the data were segmented according to the facial biotype and the dental status. The accurate prediction of the sex considering the targeted model in relation to the facial biotype is 63.7%.

In addition, have no influence of the dental status in the model, and the accuracy rate was higher in total dentate (71.3%). When were considered the dental status and facial biotype together, the percentage of correct percentage was 69%.

DISCUSSION

To ensure the reliability of linear measurements, in this study we used only panoramic radiographs of high quality with minimal image distortion, since small changes in anteroposterior displacement and tilt sample are associated with a range of up to 2% to mandibular measurements in the vertical plane (Xie *et al*., 1996). In addition, Batenburg *et al.* (1997) showed that angular measurements in the mandible on panoramic radiographs

reveal a high degree of accuracy when they present minimal distortion. Moreover, both sides do not overlap in this type of examination, which does not happen in the lateral radiograph (Zangouei-Booshehri, 2012).

Studies involving linear measurements are needed to assess sexual dimorphism in the morphology of the mandible in different populations and contribute to human identification. Factors such as the biomechanical adaptations of the masticatory system, muscular structure and genetic, regional factors, and evolving food habits or the interrelation of these can be associated with specific mandibular morphological characteristics of each population (Anderson, 1998; Prado & Caria 2007).

Logistic regression analysis aims to produce allows predicting the values taken by a categorical variable, often binary, from a continuous series of explanatory variables and / or binary (Patil & Mody, 2005). This statistical method can be seen that the correct prediction of sex considering the segmented model in relation to biotype is 63.7%, and there were more misses in predicting the sex of dolichofacials, and the accuracy of the model was better for others biotypes. Furthermore, it was found that there was an influence on the model of the dental condition, and the hit rate was higher in all teeth (71.3%). When were considered dental condition and facial biotype together, the percentage of correct answers was 69%.

In the present study, in general, female sex showed more obtuse gonial angle than male sex. It is suggested that this result was due to the greater contractility of the masseter and medial pterygoid muscles in male than in female sex. The greatest contraction force of these muscles makes the mandibular branch more straight in male sex generating of gonial angle approaching a straight angle, while the gonial angle in female sex becomes more obtuse (Xie & Ainamo, 2004). This also explains the fact that the male sex showed a higher value for the posterior curvature of the mandibular branch to male sex than the female sex.

The shape, size and symmetry of craniofacial structures diversify depending facial biotype. The facial biotypes are important for treatment planning in several dental clinical situations and too predict growth and orthodontic planning. In Forensic Dentistry the dolichofacial (vertical growth), mesofacial (balanced growth) and brachyfacial (horizontal

growth) biotype can influence the structures of the skull morphology like ethnic and sex characteristics and influence the human identification (Arslan *et al*., 2008). There is an established relationship between sexual dimorphism and facial biotype have found by several authors (Schudy, 1965; Bishara & Jakobsen, 1985; Nanda, 1990). Here, the dolichofacials expressed more obtuse gonial angle that brachy and mesofacials individuals, with no statistically significant differences between the meso and brachyfacials. However, electromyographic studies (Ingervall *et al.,* 1974) showed that the highest activity of the masseter muscle and the anterior fibers of the temporalis muscle is associated with a higher facial height and lower angle, showing that, in the present study, the most influential factor on gonial angle was the presence of teeth (Bakke *et al.,* 1990), and the full dentate showed higher values for this structure than edentulous and partially dentate. Morphological differences between dolicho and brachyfacials individuals resulted in significant differences in the mechanical advantage of the masticatory muscles. As gonial angle is greater in individuals dolichofacials, the mechanical advantage of the masseter and medial pterygoid muscles decreases and vice versa (Mangla *et al*., 2011).

The present study revealed the influence of the dental status only to antegonial angle. In general, full dentate individuals demonstrated the most obtuse angle that partially dentate , with no statistically significant differences between dentate and edentulous and partially dentate. The dental status also influenced the depth of antigonial angle. Thus, full dentate had less depth than the edentulous and partial dentate, so that there were no statistically significant differences between. The increasing of antegonial angle and its depth with the loss of teeth reveals a pattern of bone resorption in edentulous mandibles, which probably is accentuated due to bony deposition in the anterior mandible (Xie *et al.,* 1996; Dutra *et al*. 2004). Lambrechts *et al*. (1996) have shown, by cephalometric measurements, the relationship between changes in the depth of antegonial angle and the increased bone deposition in the anterior mandible.

Changes in antegonial angle were not found in gonial angle. The antegonial angle showed bone remodeling in edentulous individuals, probably due to decreased muscle function in this region by the teeth loss, compared with the gonial angle. Muscle function tends to preserve bone in its insertion point, so the bone structure of the gonial angle is

maintained by the insertion of the medial pterygoid and masseter muscles, even after teeth loss (Dutra *et al.*, 2004). In general, compared to antegonial angle only its depth showed sex influence, where men showed higher values than women. Ghosh *et al*. (2010) affirmed that there is an intrinsic relationship between the increase in depth antegonial angle and muscle function reduced. As male sex presents higher strength and power in the elevator muscles of the mandible, we suggest a tendency to have a higher bony resorption in depth antegonial angle.

CONCLUSION

In conclusion, mandible can be used for sex determination in Brazilian population by the proposed method, with greater or lesser degree of accuracy according to the analyzed variables (dental condition and facial biotype).

However, further research is required to improve the methodology applied, in order to assist forensic experts in human identification.

ACKNOWLEDGEMENTS

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CONCLUSÃO

- Não havia informações sobre o tempo de perda de dentes e uso de prótese, e por isso esses fatores não puderam ser considerados para inclusão / exclusão no trabalho.

- A previsão correta de sexo, considerando o modelo segmentado em relação ao biotipo é de 63,7%, e, além disso, houve influência da condição dentária, e a taxa de precisão foi maior nos dentados totais (71,3%).

- Em posse de uma radiografia panorâmica de um indivíduo brasileiro, é possível prever o sexo de 62% de precisão, considerando o biotipo facial e condição dentária dele.

- A limitação deste estudo é a miscigenação racial que ocorre na população brasileira. Para isso, as variáveis avaliadas neste estudo devem ser investigadas em estudos futuros.

- Apesar desta limitação, outros estudos com esta população devem ser feitos, uma vez que as tabelas desenvolvidas para populações mais homogêneas não podem ser aplicadas no Brasil.

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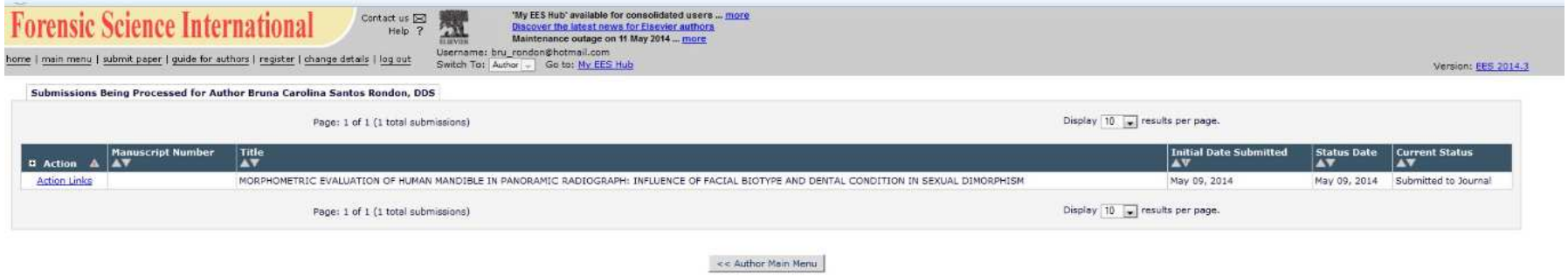

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ANEXO 2 – CERTIFICADO DO COMITÊ DE ÉTICA EM PESQUISA DA FOP-UNICAMP

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CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa **"Morfologia mandibular e sua relação com o biótipo facial e condição dentária para a determinação do sexo"**, protocolo nº 094/2012, dos pesquisadores Bruna Carolina Santos Rondon, Eduardo Daruge Júnior e Felippe Bevilacqua Prado, satisfaz as exigências do Conselho Nacional de Saúde - Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 14/11/2012.

The Ethics Committee in Research of the School of Dentistry of Piracicaba - State University of Campinas, certify that the project **"Mandibular morphology and its relation with different facial types and dentition for sex determination"**, register number 094/2012, of Bruna Carolina Santos Rondon, Eduardo Daruge Júnior and Felippe Bevilacqua Prado, comply with the recommendations of the National Health Council - Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee at 11/14/2012.

Lívia M. A. Tenuta
Profa. Dra. Lívia Maria Andaló Tenuta
Secretária
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Coordenador
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Notice: The title of the project appears as provided by the authors, without editing.