

Analysis of bone mineral loss by dental panoramic radiography in men over 40 years old in the state of Roraima

Análise da perda mineral óssea por radiografia panorâmica dentária em homens com mais de 40 anos de idade no estado de Roraima

DOI:10.34117/bjdv8n5-017

Recebimento dos originais: 21/03/2022

Aceitação para publicação: 29/04/2022

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ABSTRACT

Background: The present study was conducted to understand the possible application of panoramic radiography as an alternative diagnostic measure for the detection of osteopenia and osteoporosis. Moreover, we surveyed to understand the oral hygiene of the participants. **Materials and Methods:** A questionnaire-based survey for self-assessment was done, followed by a detailed radiographic evaluation and Cortical Mandibular Index (ICM) and Mentonian Index (IM) recording. Later, statistical analyses were done for descriptive analysis and possible important factors responsible for the obtained ICM and IM values. **Results:** The obtained results suggested that for the present study population of 112 participants, and considered 25 parameters, age was a major factor (P 0.00456) along with the use of a personal toothbrush (P 0.01265), and exchange of a new toothbrush (P 0.0293). These factors were significantly influential on the ICM outcomes (P 0.06645) whereas the influence of the considered parameters was not significantly influential on IM results. **Conclusion:** The descriptive results suggested that osteopenia and osteoporosis were dominant among the patients as

confirmed by the radiographic analysis. Hence, panoramic radiography can be an effective alternative in the diagnosis of osteoporosis. However, confirmation should be obtained from further large-scale studies on diverse populations with more contributing factors.

Keywords: osteoporosis, osteopenia, cortical mandibular index, mentonian index, bone mineral density, dental radiography.

RESUMO

Antecedentes: O presente estudo foi realizado para compreender a possível aplicação da radiografia panorâmica como uma medida alternativa de diagnóstico para a detecção de osteopenia e osteoporose. Além disso, realizámos um inquérito para compreender a higiene oral dos participantes. **Materiais e Métodos:** Foi feito um inquérito baseado num questionário para auto-avaliação, seguido de uma avaliação radiográfica detalhada e do registo do Índice Mandibular Cortical (ICM) e do Índice Mentoniano (IM). Posteriormente, foram feitas análises estatísticas para análise descritiva e possíveis factores importantes responsáveis pelos valores obtidos do ICM e do IM. **Resultados:** Os resultados obtidos sugeriram que para a população do presente estudo de 112 participantes, e considerando 25 parâmetros, a idade foi um factor importante (P 0,00456) juntamente com a utilização de uma escova de dentes pessoal (P 0,01265), e a troca de uma nova escova de dentes (P 0,0293). Estes factores tiveram uma influência significativa nos resultados da MI (P 0,06645), enquanto que a influência dos parâmetros considerados não teve uma influência significativa nos resultados da MI. **Conclusão:** Os resultados descritivos sugeriram que a osteopenia e a osteoporose eram dominantes entre os pacientes, tal como confirmado pela análise radiográfica. Assim, a radiografia panorâmica pode ser uma alternativa eficaz no diagnóstico da osteoporose. No entanto, a confirmação deve ser obtida a partir de mais estudos em larga escala sobre diversas populações com mais factores que contribuam para isso.

Palavras-chave: osteoporose, osteopenia, índice cortical mandibular, índice mentoniano, densidade mineral óssea, radiografia dentária.

1 INTRODUCTION

The global prevalence of bone diseases such as osteoporosis is on the rise. Osteoporosis is known as a silent disease that does not have any specific symptoms.^[1,2] The disease condition and the contributing factors are complex and numerous that tremendously affects the quality of life of the patient.^[3] The diagnosis of the disease condition becomes cumbersome due to the lack of prominent symptoms of osteoporosis.^[4,5] The patient outcome significantly varies with the timely diagnosis and treatment measure adopted.^[6] The bone mineral density (BMD) measurement is the specific diagnosis measure for such silent bone disease conditions.^[7] As several factors can be responsible for such bone disease onset and progress, negligence in different types of other medications can induce osteoporosis.^[8,9] Previously this disease condition

was prominent in females, especially around the menopausal age,^[10] however, it was later established that males are also prone to osteoporosis due to certain reasons including age.^[11] Several health conditions including dental health have been associated with the osteoporotic disease condition.^[12,13] Hence, detection of dental health, especially the jaw bones and gums through panoramic radiographic examination, and BMD can be used as an alternative diagnosis or phenotypic marker for osteoporosis.^[14] Osteoporosis is a prevalent health condition in Brazil.^[15] The burden of the disease is growing with time.^[16] The existing scientific literature suggests that most of the research has been conducted on female patients compared to males.

In the present study, we have attempted to understand the prevalence of osteopenia and osteoporosis through examining the dental hygiene, and self-evaluation report in the males of Roraima province in Brazil. The study was conducted due to the lack of scientific evidence of osteoporosis in males in this region. Hence, the analysis of osteoporosis in males is mandatory to understand the spread of the disease in the population. Bone densitometry is an expensive diagnostic measure for the disease, often; patients with poor social backgrounds cannot afford such a diagnosis. Therefore, panoramic radiography can be a cost-effective alternative if the diagnosis measure can be implemented for the detection of the disease condition.

The present prospective study was designed to analyze the feasibility of the use of the morphometric indexes of panoramic dental radiographs (Cortical Mandibular Index and Mentonian Index) as a substitute diagnosis method for osteopenia and osteoporosis detection in men over 40 years of age. The secondary objective of the study was to evaluate the oral hygiene habits of men in the capital of the state of Roraima. The research outcomes obtained in this study were insightful and provided valuable and encouraging information to consider the panoramic radiography as a possible diagnosis measure for osteoporosis and osteopenia detection. Age and other important factors were found to be crucial in understanding the grade of the disease.

2 MATERIALS AND METHODS

The objective of the present study was to understand the impact of various demographic, social, and oral hygiene associated factors on oral health as expressed by the panoramic dental radiography measured by the cortical mandibular (ICM), and Mentonian (IM) indexes.

2.1 ELIGIBILITY CRITERIA

In the present study, the patients with age >40 years were considered eligible to participate. Only those patients were considered who consented to be part of the experiment after receiving the written statement about the study purpose details from the principal investigator or the medical staff. Moreover, those who agreed to sign the Informed Consent Form (ICF), developed in accordance with resolution 466/2012 of the National Council of Health (CNS) were the selected participants. Patients who earlier consulted from the Policlínica Cosme e Silva (PCS), in the city of Boa Vista, RR province were only considered. Patients not willing to be a part of the research, having cognitive impairments, and patients having other personal or professional reasons were excluded from this study.

2.2 STUDY LOCATION AND DATA COLLECTION

The study was conducted at the Policlínica Cosme e Silva (PCS), in the city of Boa Vista, RR province. The initial estimated target was to have around 300 participants for the study. However, the final dataset contains 112 participants after following the strict eligibility criteria. All data were recorded following the standard clinical survey norms and the dataset was assembled in a spreadsheet. Later, considering the necessity of the analysis the categorical data were coded following the requirement.

2.3 DATA SOURCES

The study considered demographic data, data retrieved from the mentioned questionnaire, and the data obtained from the panoramic radiography examination conducted for each patient.

2.4 QUESTIONNAIRE

Each participant was evaluated using a validated oral health questionnaire proposed by the Oswaldo Cruz Foundation (Fiocruz). The set of questionnaires had the basic questions about oral hygiene, frequency of brushing, difficulties in feeding, and visits to the dentist.

2.5 PANORAMIC RADIOGRAPHY DATA COLLECTION

Apart from the questionnaire-based survey all patients were subjected to the panoramic radiograph using the ICM and IM methods. All research participants were

exposed to ionizing radiation in safe doses in dental clinics as part of their routine evaluation. Every safety measure was carefully implemented for the medical professionals and the patients. A developed consistent protocol was followed for each patient while performing the panoramic radiography.

The health protection of the examiner and the patients who underwent the examinations were carefully considered and the use of a lead apron and thyroid protector was employed for the protection of the patients. The panoramic radiographic examinations were carried out at the Dental Specialties Center-State CEO, through a partnership signed with the State Health Secretariat (SESAU). The term of consent for this study was signed with the coordinator of the CEO, the manager of the Medium-sized Health Unit, and the General Coordinator of Specialized Care. The radiographs were performed by a dental surgeon who was specialized in radiology. The radiographs were conducted following the best practices considered routinely at the clinic. The State CEO is on the premises of Policlínica Cosme e Silva in Bairro Pintelândia.

The digital X-ray imaging system, model number PaX-400C, tube type D-051 / TOSHIBA, a focal point of 0.5 mm IEC 336, inherent filtration applied was of 0.8 mm Al, the total filtration of 2.8 mm Al, was used to capture the required information for each patient. The serial number of the used system was XG-003-1800. The exposure angle used was 220°.

The patient was positioned upright, and the captured image was enlarged in panoramic mode (1.30: 1). The X-ray exposure time considered was 14 seconds for each case, and the exposure was 68 kWp, 8 mA as recommended for males. The EasyDent4 viewer software was used for capturing the information.

The computer system used an Intel Core I5 computer with a 3.20 GHz processing speed and 4 GB of RAM for viewing the radiographic examination and obtaining the indexes of radiomorphometric. In this study, the biowaste generated was PPE, protective plastics, and others, which were later disposed of properly following the protocol described in the current PGRSS (Health Services Waste Management Program). In the present study, the radiographic examinations conducted were completely digital; hence, the experiments reduced the waste generated and were cost-effective as well. After obtaining the panoramic radiography, the radiologist determined the radiomorphometric indices through a written report.

The Mandibular Cortical Index (ICM) is considered a qualitative and visual way of clinical evaluation, and the degree of resorption of the endosteal margin of the

mandibular cortex. The obtained results were presented as C1-Normal (clear and sharp margin on both sides), C2-Osteopenia (semilunar defects or cortical residues), and C3-Osteoporosis (reduced and porous thickness).^[12,13]

The Mentonian Index (IM) was conducted to evaluate the thickness of the mandibular cortex, it was measured on a line perpendicular to the base of the mandible, and at the height of the center of the mental foramen, where the normal value is greater than or equal to 3.1.^[12] After this stage, the radiomorphometric indices of the mandible were correlated with the bone mineral density of the spine and the femur of the patients that were obtained from the bone densitometry data.

2.6 PATIENT DEMOGRAPHIC DATA COLLECTION

All the patients were required to fill the data record properly, and they were instructed with all possible information for the ease of the task. The mandate form was containing questions about his/her oral conditions, with specific fields for recording the participant's data. The data were recorded effectively to facilitate the analysis using appropriate statistical measures.

2.7 DATA ASSEMBLING AND STATISTICAL ANALYSIS

The collected data of 112 male patients were tabulated in a Microsoft® Excel spreadsheet. Later, the data were analyzed using descriptive statistics, and inferential statistical analysis was conducted using regression analysis. The obtained results were considered significant at the level of significance of 5% ($p < 0.05$). The statistical analyses were conducted using SPSS (version 25), and R 3.6.

The research outcomes are expected to provide benefits to the society and the participants since they will have free access to a panoramic examination in which asymptomatic bone and dental pathologies can be diagnosed.

2.8 ETHICAL CONSIDERATION

Following the protocol for human research, appropriate ethical approval was obtained from the Human Research Ethics Committee (Plataforma Brasil) (Ethical approval number: 26385919.7.0000.5301). All data collected from each of the patients with their respective consent was kept confidential.

No questions, outside the standard questionnaire set, was used that may cause any discomfort or embarrassment to the patients. The patient data were collected on the

same date of their respective radiography appointment. The data was collected by the author of this study directly from the patient through the questionnaire and their respective reports of panoramic radiograph were collected with their consent.

3 RESULTS

The obtained results were analyzed in detail using descriptive and inferential statistical measures. The final assembled dataset contained information of 112 patients who were selected based on the eligibility criteria adopted for the study. A total of 25 important parameters were considered to analyze. Out of this, 7 variables were demographic factors, 2 indices (ICM and IM), and the rest of the 16 variables were derived from the survey outcomes.

3.1 DEMOGRAPHIC FACTOR ANALYSIS

The age distribution of the patients was in between 40 years and 80 years with a mean age of $50.85(\pm 9.42)$ (Figure 1). The observed minimum age of the patient was 40 years whereas the maximum age recorded was 78 years (Figure 1). The interquartile range of the age parameter was 13.50 (Figure 1C). The estimated Q-Q plot for the common age data source is presented in Figure 1D.

Comparative distribution of the social factors considered in this study concerning the age of the patients was done and the outcomes are reported in Figure 2. The analysis of the marital status of the patients with reference to age (Figure 2A) suggested a skewed outcome for all of the marriage-related aspects of the patients (1=single, 2=married, 3=stable union, 4=Separated or divorced).

The median age was higher for the single and divorced patients compared to the married and stable union patient groups (Figure 2A). Similarly, distribution of age was observed with other demographic factors such as race, smoking habit, drinking habit, education level, and income level of the selected patients (Figure 2). Asymmetric distribution was observed for each case with slightly varying median age values as presented.

3.2 SOCIAL FACTORS

All the social factors were keenly studied and the distributions of the patients were analyzed. Table 1 presents the distribution of all the social factors for the total 112 participants in the present study. It was observed that married participants ($n=59$,

52.67%), people belonging to brown skin color (n=71, 63.39%), were more in the patient group. Social habit analysis suggested most of the patients were non-smoker (n=77, 68.75%), and were not having a habit of drinking alcoholic beverages (n=53, 47.32).

The analysis of the academic pursuit of the patients suggested that more than 34% of the patients (n=39) were having a high school education, higher education was obtained by 25% of the participants (n=28). The analysis of the family income of the patients revealed that most of the patients were having an income of one to two wages (n=58, 51.78%) (Table1).

Table 1: Distribution of marital status, race, smoking habits, drinking habits, of the patients, education, and income level of the patients.

Marital status				
Marital status	Frequency	Percent	Valid Percent	Cumulative Percent
Single	27	24.107	24.107	24.107
Married	59	52.679	52.679	76.786
Stable Union	22	19.643	19.643	96.429
Separated / Divorced	4	3.571	3.571	100.000

Race				
Race	Frequency	Percent	Valid Percent	Cumulative Percent
White	22	19.643	19.643	19.643
Brown	71	63.393	63.393	83.036
Black	18	16.071	16.071	99.107
Yellow	1	0.893	0.893	100.000

Smoker				
Smoker	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	18	16.071	16.071	16.071
No	77	68.750	68.750	84.821
Stopped	17	15.179	15.179	100.000

Drinking habits				
Drinking habits	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	10	8.929	8.929	8.929
Socially	49	43.750	43.750	52.679
No	53	47.321	47.321	100.000

Apart from the social factors, a detailed stepwise survey was conducted for the patients who participated in this study. The distributions of the answers to the specific questions of the standard questionnaire used are presented in Table 2.

Table 2: Distribution of survey outcomes conducted for the oral health assessment of the male study population who were part of this study.

A) How frequently do you brush your teeth?

A	Frequency	Percent	Valid Percent	Cumulative Percent
I don't brush every day	3	2.679	2.679	2.679
Once a day	10	8.929	8.929	11.607
Two or more times a day	99	88.393	88.393	100.000

B2) Do you use toothpaste to do mouth hygiene?

B2	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	111	99.107	99.107	99.107
No	1	0.893	0.893	100.000

B3) Do you use floss to do mouth hygiene?

B3	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	56	50.000	50.000	50.000
No	56	50.000	50.000	100.000

C) Do you have a toothbrush only for you?

C	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	110	98.214	98.214	98.214
No	2	1.786	1.786	100.000

D) How often do you exchange your toothbrush for a new one?

D	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 3 months	54	48.214	48.214	48.214
Between 3 to less than 6 months	51	45.536	45.536	93.750
Between 6 months and less than 1 year	6	5.357	5.357	99.107
More than a year	1	0.893	0.893	100.000

3.3 ORAL HEALTH ANALYSIS

The assessment of oral health through the questionnaire was done with 16 different questions having logical optional answers. All these questions were related to the oral hygiene of the patients that included brushing, flossing, and other care that was taken for the better tooth and gum (Table 2).

It was observed that most of the patients were aware of the dental care and the majority of them took appropriate care of their teeth and gum. As part of the self-assessment of dental hygiene, the majority of the patients considered to have better dental health for themselves (Table 2).

3.4 RADIOGRAPHIC INDICES

A proper dental examination was carried out through panoramic dental radiographs for each patient to understand the actual dental health condition. The Mandibular Cortical Index (ICM) and Mentonian Index (IM) were considered to express the outcome of the dental hygiene evaluation through the radiographs (Table 3). The patients were categorized according to the standard classification of ICM, i.e., C1 as normal dental health with clear and sharp margin on both sides, C2 referring Osteopenia

with semilunar defects or cortical residues, and C3 representing Osteoporosis with reduced and porous thickness. The analysis suggested that majority of the patients were having various grades of Osteopenia (n=59, 52.67%), followed by normal dental health (n=45, 40.17%).

On the other hand, the evaluation through the Mentonian Index suggested that most of the patients were having Index values between 3.1 and 3.3.that comprises more than 30% of the patients. Hence, the presumption of healthy dental conditions observed during the survey was not exactly correct. The radiographic examination of the patients suggested that they have various grades of dental issues, especially Osteopenia.

Table 3: Distribution of survey outcomes for the radiographic indices, Mandibular Cortical Index (ICM), and Mentonian Index (IM) considered for the oral health assessment in this study.

Mandibular Cortical Index (ICM)				
ICM	Frequency	Percent	Valid Percent	Cumulative Percent
C1	45	40.179	40.179	40.179
C2	59	52.679	52.679	92.857
C3	8	7.143	7.143	100.000
Mentionian Index (IM)				
IM	Frequency	Percent	Valid Percent	Cumulative Percent
2.2	1	0.893	0.893	0.893
2.4	1	0.893	0.893	1.786
2.5	1	0.893	0.893	2.679
2.6	1	0.893	0.893	3.571
2.7	1	0.893	0.893	4.464
2.8	1	0.893	0.893	5.357
2.9	6	5.357	5.357	10.714
3	5	4.464	4.464	15.179
3.1	11	9.821	9.821	25.000
3.2	16	14.286	14.286	39.286
3.3	10	8.929	8.929	48.214
3.4	7	6.250	6.250	54.464
3.5	4	3.571	3.571	58.036
3.6	3	2.679	2.679	60.714
3.7	6	5.357	5.357	66.071
3.8	5	4.464	4.464	70.536
3.9	3	2.679	2.679	73.214
4	9	8.036	8.036	81.250
4.1	8	7.143	7.143	88.393
4.2	1	0.893	0.893	89.286
4.3	3	2.679	2.679	91.964
4.5	2	1.786	1.786	93.750
4.6	2	1.786	1.786	95.536
4.7	2	1.786	1.786	97.321
5	2	1.786	1.786	99.107
5.1	1	0.893	0.893	100.000

3.5 RELEVANCE OF DEMOGRAPHIC, SOCIAL, AND DENTAL HEALTH FACTORS WITH ORAL HYGIENE

The ICM (Figure 3) and IM (Figure 4) values were considered as the representation of dental hygiene and a detailed statistical regression analysis was conducted to understand the influence of other parameters on these variables. The observed statistical features are presented in Figure 3 and Figure 4. It was observed that statistically significant influence of age (P 0.00456), use of personal toothbrush (P 0.01265) (Question C: Do you have a toothbrush only for you?), and how often the patient exchanges a new toothbrush (Question D) (P 0.0293) was present on the outcome of ICM. The overall regression analysis results were found statistically significant (P 0.06645). Similarly, the regression analysis for IM (Figure 4) suggested no statistically significant influencing parameter on the IM outcomes (P 0.3058).

4 DISCUSSION

A healthy bone structure for older age is essential to have a functional and stable life. However, our daily busy life and regular activities hamper the routine care for better bone health. The common bone problems include osteopenia and osteoporosis which are being reported largely for the aging population all over the world.

Osteopenia is not considered as a disease condition rather the presence or occurrence of osteopenia suggests a probability of worse future disease conditions such as osteoporosis. The bone mineral density (BMD) measurement of hip and other skeletal structures remains the major diagnostic method to evaluate the bone mineral concentration. However, lack of bone mineral density generally does not have any major symptom, hence, most of the time it is unnoticed by the patient or the physician. The prevalence of osteoporosis is reported in many countries from time to time.^[17,18] Studies suggest that several factors such as age,^[19] female gender,^[17] Asian race or Caucasian race,^[20] smoking habit,^[21] sedentary lifestyle,^[22] lack of nutrition,^[6,23] uric acid,^[24] and different disease conditions such as diabetes influence the onset and progress of osteoporosis.^[25]

The lack of timely diagnosis due to the absence of proper specific and significant symptoms often makes the difference between the early and late treatment outcomes among the patients.^[6] Globally almost 9 million osteoporotic fractures are occurring yearly.^[26] Timely diagnosis is possible through proper awareness of the condition among the patients and physicians. A simple substitute with a comparatively cost-

effective method of diagnosis may help in the early diagnosis of this silent disease condition and allow the patient and the physician to take necessary remedial steps.

The association between dental health and osteoporosis is well established in post-menopausal women.^[27] The panoramic radiographic analysis also proved the relationship between osteoporosis, liver cirrhosis, and an abnormal jaw structure recently.^[28] The association of dental health and osteoporosis has been reported in several other studies as well and also in males.^[29-31]

Radiometric indices are being used for the mandible area assessment with different dental health-related purposes. The radiomorphometric analyses have been utilized as a plausible diagnostics tool earlier. Such indices have been used to evaluate the dental conditions of British females and diagnose skeletal osteopenia.^[32] Application of these indices has revealed the difference between inferior cortex morphology of osteoporotic patients and normal human being along with the importance of age as a contributing factor.^[33] Previous research established that mental indices and panoramic mandibular indices are the most sensible detection techniques for osteoporosis and osteopenia.^{[12].}

A systematic analysis suggested that most of the research applied panoramic mandibular index considering cut off of 0.3, while other indices such as mandibular cortical width and Klemetti index are also used in several studies.^[34] Another study reported the successful implementation of these radiographic indices in elderly patients where dental condition, gender, and these indices values were important in differentiating the osteoporotic and other patients.^[35] Moreover, the difference in such indices values was also reported among genders, age groups, and people from different geographical locations.^[36] The assessment of osteopenia and osteoporotic conditions was successfully conducted using radiomorphometric indices as a diagnostics tool on different populations, age groups, genders, and skeletal BMD prediction.^[37] Therefore, we considered these radiomorphometric indices as the evaluation tool or possible diagnostics measure for the present study for detecting osteopenia and osteoporotic condition in Brazilian male patients.

The outcome of the study suggests that even though most of the patients considered themselves healthy but they had a different grade of osteopenia and osteoporosis. Hence, the present adopted measure may serve as a possible diagnostic tool for the detection of early osteopenia and osteoporosis. Along with the factors discussed, the present study also emphasized some of the important factors such as age,

use of a personal toothbrush, use of a new toothbrush as significant factors for dental health. Radiomorphometric analysis may become an efficient alternative diagnostic tool for the detection and diagnosis of osteopenia and osteoporosis. A large cohort analysis considering similar factors in a diverse patient population may establish the results obtained in this study.

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FIGURE LEGENDS

Figure 1: Distribution of the age of the study population. (A) Male patients' age distribution between 40 and 80 years, (B) density plot of the age factor for the male patients, (C) boxplot presentation of the age parameter. (D) A theoretical Q-Q plot for the age distribution of the male patients.

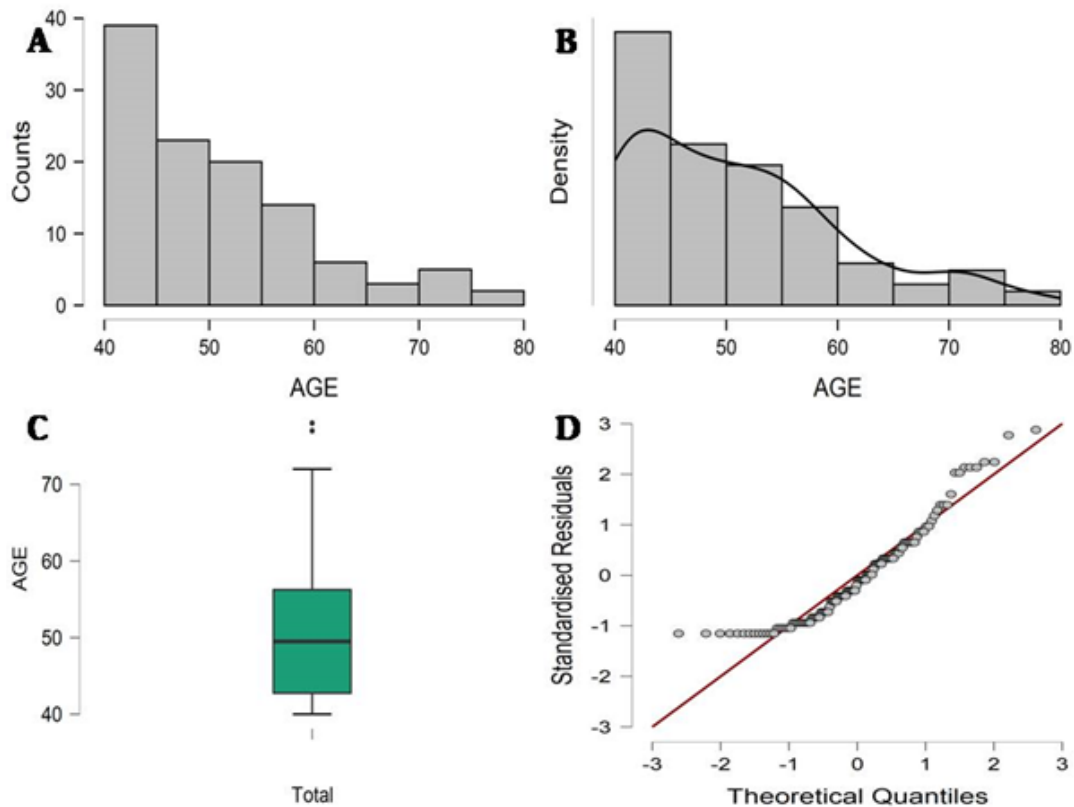


Figure 2: Distribution of the social factors such as (A) marital status, (B) race, (C) smoking habit, (D) drinking habit, (E) education level, (F) income level of the patients with reference to the age.

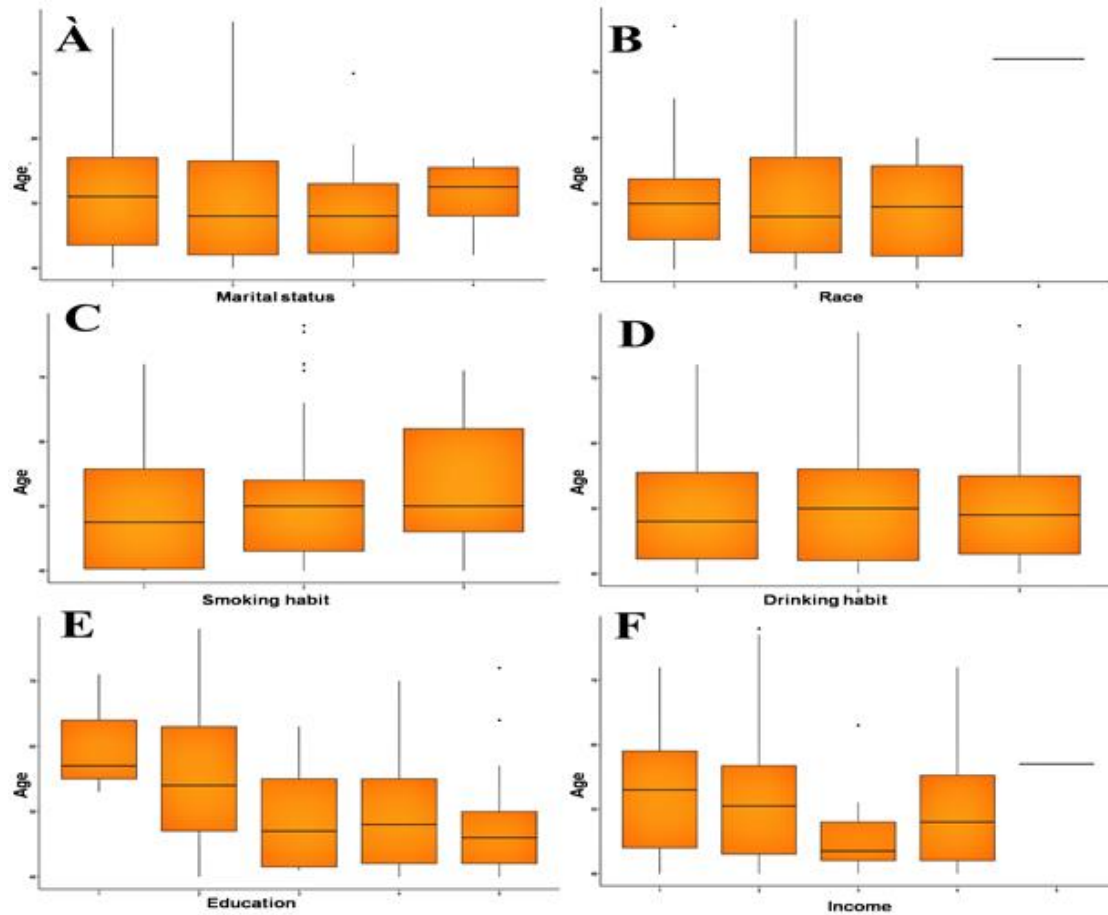


Figure 3: Multiple linear regression results for the Mandibular Cortical Index (ICM). (A) Results observed for the residual versus the fitted data, (B) the normal Q-Q plot, (C) the scale localized fitted values, and (D) residuals versus leverage observed.

