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# Evaluating Maxillary Bone Density by (CBCT) as a Tool in Implant Prognosis in Kurdish Population

Ranj Adil Jalal[1*], Azhar Ghanim Ahmed[2], Rukhosh Hasan Abdalrahim[3], Mardin Othman Rashid[4], Mohammed Abdalla Mahmood[5]

B.D.S, M.Sc. Oral and Maxillofacial Radiology. Oral diagnosis department/ College of Dentistry, University of Sulaimani, Sulaimani, Iraq[1,4]

B.D.S, M.Sc., PhD Oral Histology. Dental Basic Sciences department, College of Dentistry, University of Sulaimani, Sulaimani, Iraq[2]

B.D.S, M.Sc. Oral Histology and Biology. Dental Basic Sciences department, College of Dentistry, University of Sulaimani, Sulaimani, Iraq[3,5]

Corresponding author: 1*

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Bone density, CBCT, Kurdish population, maxilla, implant.

**ABSTRACT**

The objective of this study was to evaluate the quantitative bone density of the maxilla using Cone Beam Computed Tomography (CBCT) of Kurdish population in Sulaimani city and Comparing between bone density in the anterior, premolar, and molar areas also in relation to sex and age. A total of 140 CBCT of Kurdish population of both sexes with age range (20-80 years). At each implant site, the bone density has been assessed twice. A mean value has been taken to assign for that region in edentulous patients or partially dentate patients. One investigator has taken all the readings to eliminate any potential for bias, and the study is containing CBCT from one system. The maximum value was (1466.6 HU) and the minimum value was (23.3 HU) and the median was (532.1 HU). The result shows that there is no statistical difference between males and females (p-value 0.981), While the Kruskal-Wallis H test shows a significant difference between the regions (anterior, premolar, and molar) regions (p-value = 0.000). The anterior region shows the highest ranking followed by the premolar region and lastly the molar region. The most common bone type of upper jaw in Kurdish population was D3 and the less type was D1. The anterior region shows the highest ranking (347 HU) followed by the premolar region (275HU) and lastly the molar region (195 HU). Compared with other populations this study demonstrated that the bone density of Kurdish population was lower than others. This aids in racial determining in forensic dentistry and implant prognosis.



## 1. Introduction

The quality of the alveolar bone has been considered the most important factor in attaining high primary implant stability, which increases secondary implant stability (osteointegration), and implant success [1].

Dental implants are screwed into the jawbone and support a prosthesis. Several patient- and procedure-related criteria are required for each implant operation to be successful [2]. The primary stability now of implant placement is the most important component for success, even if there are many other aspects that might affect the clinical result of an implant, such as the implant geometry, the surgical method, the surgeon's skill, and so on [3], [4].

Several studies have claimed that poor-quality bone (soft bone) has a higher likelihood of implant Failure [5], [6].

As the achievement and maintenance of osseointegration depend critically on the mechanical behavior of the bone, several classification systems and approaches have been established for assessing bone quality and determining prognosis [1]. Depending on the proportion of cortical to the spongy bone, Lekholm and Zarb categorized bone quality into Q1 through Q4. Misch categorized bone as D1 through D4 based on the varying levels of resistance encountered during drilling operations. Misch also suggested using computed tomography (CT) to objectively quantify direct bone density values expressed in Hounsfield Units (HU). HU reflects, on a calibrated gray-level scale, the relative density of bodily tissues [7]. HUs in CT is considered as a gold standard to assess bone density [8].

Dental implant insertion has become an essential component of complete dental rehabilitation treatment strategies for edentulous individuals [9]. In individuals who are partially or fully edentulous, osseointegrated endosseous oral implants offer a predictable, efficient, and dependable way to replace missing natural teeth [10]. One of the most important factors in determining implant success is proper treatment planning. Periapical radiographs and panoramic imaging were previously the only factors used to determine implant diagnosis and treatment planning. As radiography technology develops, computed tomography (CT) and cone-beam computed tomography (CBCT) are becoming more crucial for proper implant placement, particularly in the case of complex reconstructions [11]. A thorough dental history, images, study models, panoramic and periapical radiographs, and CBCT of the potential implant sites should all be considered when assessing a patient for dental implants [12].

## 2. Aims

1. The aim of this study was to evaluate the quantitative bone density of the maxilla using Cone Beam Computed Tomography (CBCT) images of the Kurdish population in Sulaimani city.
2. Comparison between bone density in the anterior, premolar and molar maxillary areas also in relation to sex and age.

## 3. Patients and Method

A total of 140 CBCT images of Kurdish population patients of both sexes with age range (20-80 years) from (September to December 2022) has been taken at private radiology center in Sulaimani city who are referred for taking CBCT for the purpose of implant restoration.

Images were taken by a CBCT machine (Vatech Pax-I 3D smart, 2019). The exposure parameters are as follows: (94) KVp, 24 seconds, (7.8) mA, slice thickness (1mm) and (0.2) mm voxel size, and field of view (100mm x 85mm). CBCT images were viewed and interpreted with the use of Ez3D-I software by expert radiologist.

Inclusion criteria [12]: Patients attended at private center for taking CBCT for dental implant planning in Sulaimani City with ages 20-80 years.

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Exclusion criteria [12]: pregnant or nursing women, patients taking bisphosphonates or other medications, patients with active periodontal disease, any pathological bone abnormality, trauma, fracture, and patients who have worn dental implants in the past.
The density in the Hounsfield unit has been measured in (HU), and a measurement method carried out as follow:
Parasagittal sectioning has been performed for each edentulous (implant site) then three middle sections were selected for measuring density. The selected area was positioned 1mm away from bone crest and nasal floor/ maxillary sinus superior-inferiorly and 1mm away from buccal and palatal cortical wall. The mean of the three measurements were calculated for getting more precise density.

The virtual implant site has been selected to provide a 2 mm buffer from the maxillary sinus floor, and nasal floor. Using the verification tab in the NNT viewer application, bone density has determined at approximately 1 mm of the virtual implant in terms of Hounsfield units. The distal surface of the canine was the dividing line between the anterior and posterior parts of both jaws. At each implant site in each picture, the bone density has been assessed twice. A mean value has been taken to assign for that region in edentulous patients or partially dentate patients with several sites. One investigator has taken all the readings to eliminate any potential for bias, and the study is containing CBCT from one system [13].

## 4. Statistical analysis

The data has been recorded and tabulated using Microsoft Excel and analyzed with the statistical software package SPSS 26 (SPSS Inc., Chicago, IL, USA). Shapiro-wilk (W) goodness-of-fit test used to check the normality of the data, as the data was not normally distributed, Mann-Whitney U and Kruskal-Wallis H tests has been used to show differences between the age and sex groups. Cross tabulation has been used to show the distribution of data in relation to age groups and sex.

## 5. Result

The (CBCT) of 140 patients has been examined and a total of 528 implant sites have been included and examined. The readings have been recorded as Hounsfield unit (HU). The maximum value was (1466.6 HU) and the minimum value was (23.3 HU) and the median was (532.1 HU) the frequency distribution of the reading summarized in Table 1. The distribution of the data was evaluated for normality using Shapiro-wilk (W) goodness-of-fit test, and the data shows significant deviation from normality, W(528)=0.98, p value = 0.000, so non parametric tests applied to evaluate the data.

**Table 1:** Frequency distribution of bone quality values in relation to the sex and age groups of individuals.

| **Density Grouping * Sex * Age Groups Crosstabulation** | | | | | |
|---|---|---|---|---|---|
| Age Groups | | | Sex | | Total |
| | | | Male | Female | |
| 20-40 Years | Density Grouping | D2 | 2 (14.3%) | 12 (85.7%) | 14 (100.0%) |
| | | D3 | 8 (17.4%) | 38 (82.6%) | 46 (100.0%) |
| | | D4 | 9 (37.5%) | 15 (62.5%) | 24(100.0%) |
| | | D5 | 2 (66.7%) | 1 (33.3%) | 3 (100.0%) |
| | Total | | 21 (24.1%) | 66 (75.9%) | 87 (100.0%) |
| | | D1 | 1 (20.0%) | 4 (80.0%) | 5 (100.0%) |
| | | D2 | 22 (41.5%) | 31 (58.5%) | 53 (100.0%) |

| | | | | | |
|---|---|---|---|---|---|
| 40-60 Years | Density Grouping | D3 | 64 (43.8%) | 82 (56.2%) | 146 (100.0%) |
| | | D4 | 22 (42.3%) | 30 (57.7%) | 52 (100.0%) |
| | | D5 | 7 (38.9%) | 11 (61.1%) | 18 (100.0%) |
| | Total | | 116 (42.3%) | 158 (57.7%) | 274 (100.0%) |
| 60-80 Years | Density Grouping | D2 | 10 (47.6%) | 11 (52.4%) | 21 (100.0%) |
| | | D3 | 48 (51.6%) | 45 (48.4%) | 93 (100.0%) |
| | | D4 | 20 (52.6%) | 18 (47.4%) | 38 (100.0%) |
| | | D5 | 2 (13.3%) | 13 (86.7%) | 15 (100.0%) |
| | Total | | 80 (47.9%) | 87 (52.1%) | 167 (100.0%) |
| Total | Density Grouping | D1 | 1 (20.0%) | 4 (80.0%) | 5 (100.0%) |
| | | D2 | 34 (38.6%) | 54 (61.4%) | 88 (100.0%) |
| | | D3 | 120 (42.1%) | 165 (57.9%) | 285 (100.0%) |
| | | D4 | 51 (44.7%) | 63 (55.3%) | 114 (100.0%) |
| | | D5 | 11 (30.6%) | 25 (69.4%) | 36 (100.0%) |
| | Total | | 217 (41.1%) | 311 (58.9%) | 528 (100.0%) |

The result shows that there is no statistical difference between males and females (p-value 0.981), as shown in Table 2 which is the result of the Mann-Whitney U test. While Kruskal-Wallis H test shows a significant difference (p value = 0.000) between the regions (anterior, premolar and molar) regions. The anterior region shows highest ranking followed by the premolar region and lastly the molar region (Table 3).

**Table 2:** Sex distribution of the (HU) records and the result of Mann-Whitney U test.

| Ranks | | | | | Mann-Whitney U |
|---|---|---|---|---|---|
| | Sex | N | Mean Rank | Sum of Ranks | p-value = 0.981 |
| HU unit | Male | 217 | 264.68 | 57436.50 | |
| | Female | 311 | 264.37 | 82219.50 | |
| | Total | 528 | | | |

**Table 3:** Kruskal-Wallis H test (Ranking and statistics) to compare (HU) of the three regions.

| Ranks | | | | Kruskal-Wallis H test |
|---|---|---|---|---|
| | Regions | N | Mean Rank | |
| HU unit | Anterior Region | 124 | 347.60 | df (2)<br>p-value = 0.000 |
| | Premolar Region | 219 | 275.83 | |
| | Molar Region | 185 | 195.39 | |

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| | | | | |
|---|---|---|---|---|
| | Total | 528 | | |

The result also shows no statistical differences between the age groups using Kruskal-Wallis H test (df = 2, p value=0.233) (Table 4).

**Table 4:** Differences among age groups regarding the (HU) using Kruskal-Wallis test.

| Ranks | | | | |
|---|---|---|---|---|
| | Age (Years) | N | Mean Rank | Kruskal-Wallis H test |
| Mean | 20-40 | 87 | 266.75 | df (2)<br>p-value = 0.233 |
| | 40-60 | 274 | 273.70 | |
| | 60-80 | 167 | 248.24 | |
| | Total | 528 | | |

Misch classified the bone density into five groups based on number of Hounsfield units (HU), using (D1-D5) scoring when D1 is the highest number and have the value of >1250 HU, followed by D2 (850-1250) HU, D3 (350-850) HU, D4 (150-350) HU, and finally D5 <150 HU [14].

Figure 1 shows the distribution of the type of the bone in our sample, the most common bone type was D3 (285 locations 53.98%), followed by D4 (114 locations 21.59%), D2 (88 locations 16.67%), D5 (36 locations 6.82%), and finally D1 (5 locations 0.95%).

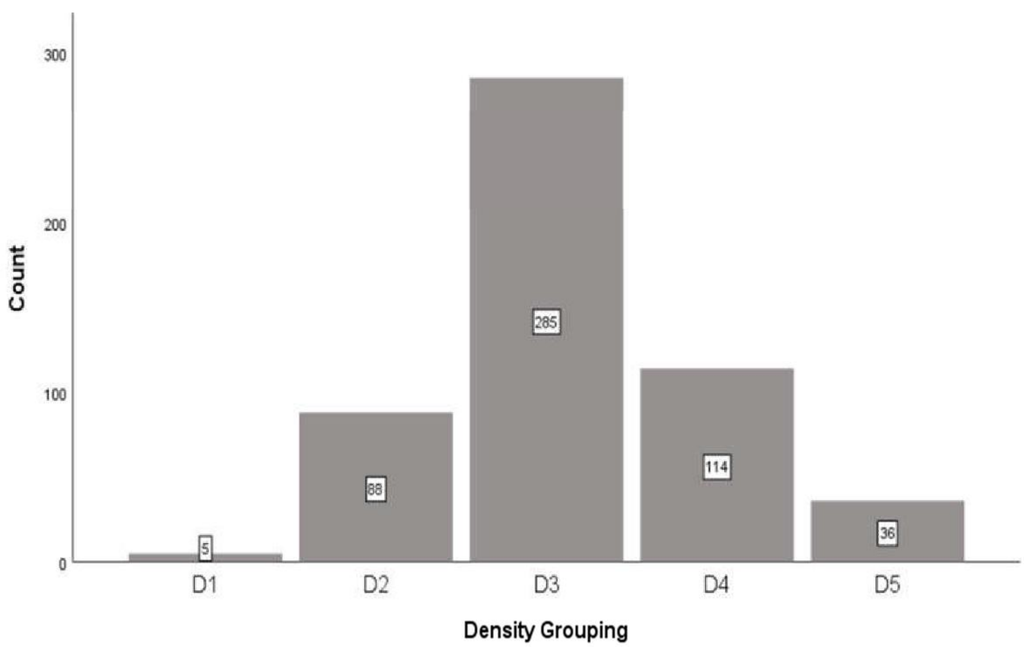


**Figure 1:** Bar count for the distribution of the sample according to the type of bone.

Figure 2 and 3 are showing the distribution of the bone density classification according to the age groups and sex, the most common bone type among all age groups was D3, followed by D4, D2, D5, and D1 respectively in both groups, while according to the locations of the examined sites, the quality of the bone was as follow: D3 was the most common type followed by D2 in anterior region and D4 in premolar and molar regions (Figure 4).

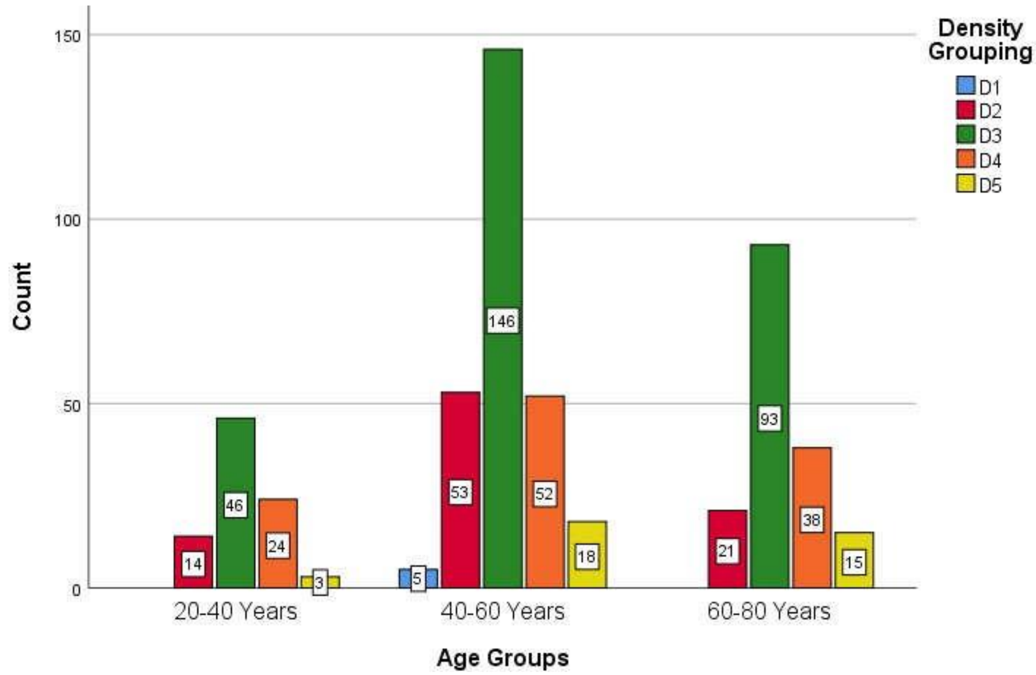


**Figure 2:** The distribution of bone classifications according to the age groups.

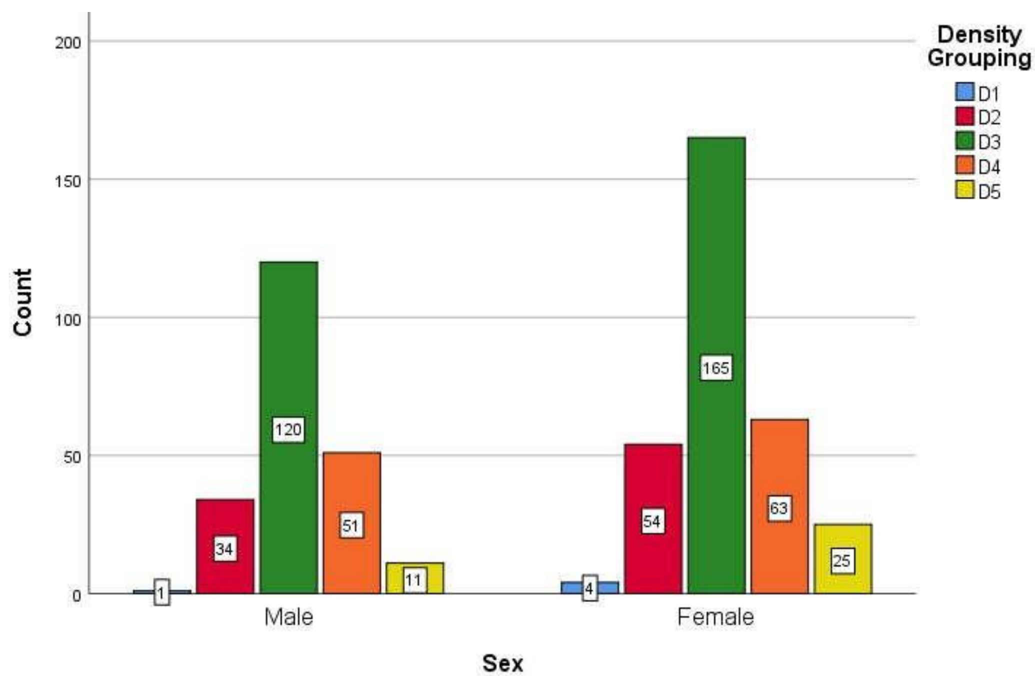


**Figure 3:** The distribution of bone classifications according to the sex of individuals.

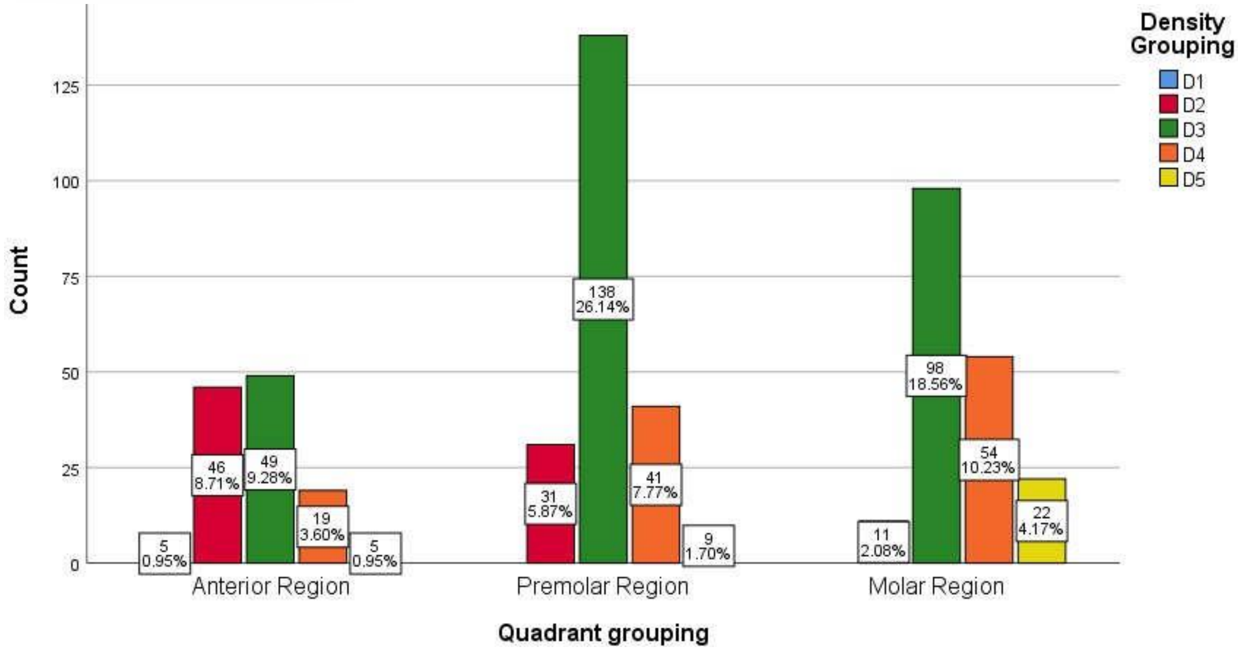


**Figure 4:** The distribution of bone classifications according to the maxillary arch quadrants.

## 6. Discussion

An objective assessment and a site-specific examination of bone density before implant placement may offer clinicians valuable information for the selection of implant size and drilling protocol [15]. Therefore, bone density assessment is crucial prior to every implant case to ensure the success of the treatment.

In this study, the density measurements were more precise due to measuring the density at three sections in each implant site and calculating the mean of those measurements.

The result concluded that the difference is not significant from the statistical point of view between males and females, this result in one line with other studies [1], [16]  while disagree with others [2], [16].

This result can be explained by the presence of estrogen hormone in higher levels in the female subjects compared to the male subjects which is compensated by the exercises exerted by the males and the different chewing patterns [17, 18].

Several studies [1], [19] have demonstrated no statistical variances between different ages, this result come to an agreement with our study furthermore others showed contrary [2], [6].

The age differences can be attributed to the normal bone physiology and histology [20], and by changes in functional capacity, because maximum bite forces, masticatory muscle size, and muscle activity all tend to increase with age considering that muscle conditioning has a positive effect on bone density [21].

According to the quality of bone assessed, the most common bone type was D3 and less one D1. The anterior region shows the highest ranking followed by the premolar region and lastly the molar region.

Depending on whether t bone density classification of Misch’s HU values, the most common bone density type observed in this study was categorized as D3 and D2 with slight differences between them for anterior maxilla while most cases were D3 in the premolar region, in another hand most cases of bone type for the molar region was D3 followed by D4. These density scales would act as a prognostic indicator of the expected outcome and help clinicians to modify the treatment plan including loading protocols.

These variations in bone density between different regions could be due, on one hand, to the difference in functions fulfilled by the two jaws, and, on the other hand, to the different muscle insertion sites, which differ from region to region [15].

Comparing the present study and other studies, there are large differences between the mean of jawbone density in terms of Hounsfield Units; in the Kurdish population using CBCT for dental implant treatments, it was (347 HU) for the anterior maxilla, while in other populations showed higher bone density (Pakistan population [13] was 709.7525 ± 122.634 HU, Turkey population [6] was 715.8 ± 190 HU, Chinese patients [22] was (530 161 HU), Myanmar population1 was 439 ± 271HU and USA [19] was 517 ± 177 HU for the anterior maxilla).

Furthermore, the mean bone density at the maxillary posterior region was lower than other reported studies (population) UK [23] (417.3 ± 227.3HU), USA [19]. was (333 ± 199HU), Pakistan [13] was (299.66 ± 73.090 HU), Turkish population [6] was 455.1+/-122 HU, Saudi Arabia (24) was (320.05 ± 193.6HU). Myanmar population3 was 271 ± 143 HU, Chinese patients [22] was (332 ± 136 HU).

This discrepancy may result from method of measurements, as in this study; the maxillary arch divided in to three regions which is different to what has been done before. In the present study, the posterior maxilla has been divided into premolar and molar area which is more precise bone density for each segments (implant insertion) beside that the racial differences, nutritional habits and drinking water may play an important role for this variation.

Additionally, this discrepancy may result from the differences in patient's age, bone mineral, density and gender, which have been, reported in previous studies [6], [25].

According to this study, the more successful rate area for implant stability was the anterior of maxilla due to the measurements, which was ranged from HU ± 200 and HU ± 600, intermediate values (D2/3) are suitable conditions for osseointegration [13]. Since a close relationship has been reported in patients with poor bone density having increased implant failure rates, [26] recorded 35% for type 4 bone density. The more porous bone in D4, which is not suitable for implantation, more than 80% of the edentulous posterior maxilla consisted of porous cortical crest or no cortical bone [27], in addition to that type D1, has an increased risk of overheating during installation of the dental implants [28].

**7. Conclusions**

The most common bone type of upper jaw in Kurdish population was D3 and less one D1. The anterior region shows highest ranking (347 HU) followed by the premolar region (275HU) and lastly the molar region (195 HU). Comparing with other population this study has demonstrated that bone density of Kurdish population was lowered than others. This aids in determining the race in forensic dentistry and implant prognosis.

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