Original Article

# Comparison of Mandibular Dental and Basal Arch in Class I and Class II Malocclusions Using Cone-Beam CT

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## Abstract

**Introduction:** Considering the importance of basal bone and dental arch for selecting the treatment plan of orthodontic patients, the present study aimed to assess basal bone and dental arch indexes in Class I and II patients by using CBCT imaging. **Methods:** Regarding the present study, the CBCT images related to 66 patients referred to the radiology department of Tabriz Dental School and had Class I (0<ANB<4) and Class II (ANB>4) skeletal and molar relationship were selected. The age range of patients was 15-35 years. The data were statistically analyzed in SPSS 23 software in order to evaluate the dental and bone indexes of intercanine and intermolar in patients with Class I and II malocclusion. **Results:** The dental indexes of intercanine width and ratio and intermolar depth related to Class II patients were obtained higher compared to those in Class I ones ($p<0.05$), while the intermolar ratio of Class I patients was determined more than that in Class II ones ($p<0.05$). The higher intermolar width and ratio were observed in Class I patients ($p<0.05$), while the greater basal arch index of intermolar depth was attained in Class II patients ($p<0.05$). **Conclusion:** Transverse dental and basal indexes are consistent, along with a difference in intercanine depth. Regarding dental and bone indexes, a strong correlation between intercanine width, intermolar depth, intermolar ratio and intermolar width and a moderate correlation in intercanine depth are observed in both groups based on correlation results.

**Keywords:** Dental arch, Basal bone arch, Class I malocclusion, Class II malocclusion, CBCT

## Introduction

The size and shape of dental arch are considered as important for orthodontic diagnostics and treatment. Most orthodontists know that the shape of basal bone affects developing dental arch [1]. The most common complication in orthodontic treatment, relapse, is probably related to the shape of basal bone [2]. Basal bone is usually assessed by measuring the apical third of root or a certain distance from gingival edge to muco-Gingival Junction (MGJ) on dental cast [3]. Lundstrom introduced "apical base" term to represent the junction of the alveolar and basal bones of the maxilla and mandible around the apex of tooth in 1925 [4].

By emerging CBCT, new landmarks were defined to determine basal bone and dental arch indexes in images [5].

Gupta et al. compared mandibular teeth and the shape of dental and bone arches in adults and children with Class I and II malocclusion by using a scanned 3-D computer model. He found that mandibular intercanine (IC) width in Class II is significantly higher compared to that in Class I, as well as Class I malocclusion in adults in greater than that of children [1].

Considering the comparison of the shape of dental and bone arches in patients with normal occlusion and Class III malocclusion, Suk et al. reported that the intercanine (IC) index related to mandibular basal bone in Class III

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malocclusion is more than that in normal occlusion significantly [6].

To date, most studies were conducted on 3D computer models, cephalometric and 2D radiographies. Further, they mostly focused on dental indexes instead of bone ones [3, 7-21]. Thus, considering the importance of bone indexes for selecting treatment plan, their effect on treatment relapse, contradictory results, weakness of conducted studies with respect to the size of sample, selection of different landmarks and precision of study, the present study sought to assess and compare basal bone indexes in Class I and II patients by using CBCT imaging.

## Method

Regarding the present study, the CBCT radiographies related to 66 patients with Class I and II skeletal and molar relationship referred to the radiology department of Tabriz Dental School were selected, of which 33 samples were divided into Class I and II. The age range of patients was determined 15-35 years. The inclusion criteria were the lack of missing teeth, cross bite, extracted teeth in the mandible, impacted teeth in mandibular anterior region and extended proximal caries, and presence of permanent teeth. Further, the exclusion criteria were regarded as the experience of fixed orthodontic treatment and ortho-surgery, obvious facial asymmetry, trauma in head and neck region, dental crowding>5mm and spacing<2mm.

The CBCT images related to the intended patients possessing Class I (0<ANB<4) or Class II (ANB>4) skeletal and molar relationships and Jaraback index between 62-65% were selected. Primarily reconstruction from data was conducted in NNTviewer software. Then, DICOM files were converted into Romexis software which facilitates the rotation of images along coronal and sagittal axes. Regarding the selection of recognizable landmarks as artificial borders, the cement-enamel junction of first molar and premolars was rotated on sagittal and axial dimensions until the system become parallel with x axis. The point contact of mandibular canine incisors (MCI) was assumed as the origin of x, y and z axes. X axis or horizontal plan was considered as parallel with occlusal plan and the apex of the mesiobuccal cusp of mandibular first molars and MCI. Mid-sagittal plane (y axis) was a line passing through MCI and is parallel with the line which connects ANS and PNS. Z axis or vertical plane was regarded as perpendicular to x and y axis.

The FA points of mandibular molar from right to left sides were used to assess dental arch dimensions in CBCT scans and root center in a transverse cut which is parallel with occlusal plan and the coronal third of the root of canine tooth was utilized for evaluating basal arch dimensions. To this end, the results were reported by using descriptive statistics (average±SD). Based on the results of normality test in Class I and II patients, the average of quantitative indexes with normal and non-normal distribution were compared by using independent t-test and Mann-Whitney U test as a non-parametric test, respectively. Further, probability values< 0.05 were considered as significance. The data were analyzed in SPSS 23 software.

## Results

The present cross-sectional study included 66 samples, of which 33 samples divided into Class I and II. The descriptive statistics related to basal bone and dental arch indexes involved the depth, width and ratio of IC and intermolar (IM) and their ratio.

The normality of data distribution was assessed by using Kolmogorov-Smirnov test, by representing normal distribution in the basal bone and dental index of IM width, dental arch index of IM ratio and basal bone index of IM depth (p>0.05) and non-normal distribution in other indexes (p<0.05).

Regarding the average of the dental arch index of IC depth and basal bone indexes of IC depth, width and ratio, no significant difference was observed (p>0.05), while there was a significant difference among other indexes in both Classes of patients (p<0.05).

Based on correlation results, a positive significant correlation was reported in all indexes instead of the basal bone and dental arch index of IC ratio. Further, there was a strong correlation between the dental and bone indexes of IM ratio, IM depth, IM width and IC width, as well as a moderate correlation among the dental and bone index of IC depth in both Classes.

**Table 1.** Dental and basal IC and IM dimensions in Class I and II

| | Dental arch | | | Basal bone | | |
|---|---|---|---|---|---|---|
| | **Class I** | **Class II** | **p-value** | **Class I** | **Class II** | **p-value** |
| **IC width** | 29.54±2.02 | 31.99±4.17 | <0.001 | 24.15±1.95 | 25.83±4 | 0.009 |
| **IC depth** | 4.91±1.08 | 4.43±0.96 | 0.012 | 4.94±0.98 | 5.29±0.99 | 0.040 |
| **IM width** | 57.96±3.77 | 54.84±4.13 | 0.2* | 52.23±3.86 | 49.54±4.19 | 0.2* |
| **IM depth** | 27.21±3.31 | 28.41±4.94 | 0.041 | 27.34±2.87 | 29.91±4.92 | 0.2* |
| **IC ratio** | 6.26±1.21 | 7.55±2.07 | 0.002 | 5.01±0.77 | 4.96±1.21 | 0.039 |
| **IM ratio** | 2.17±0.24 | 1.97±0.32 | 0.157* | 1.92±0.21 | 1.68±0.24 | 0.010 |

**Table 2.** The correlation of basal bone and dental arch indexes

| Index | Correlation coefficient | | |
|---|---|---|---|
| | Class I | Class II | Overall |
| **IC width** | 0.846 | 0.813 | 0.832 |
| **IC depth** | 0.558 | 0.507 | 0.468 |
| **IM width** | 0.928 | 0.846 | 0.896 |
| **IM depth** | 0.733 | 0.944 | 0.876 |
| **IC ratio** | 0.157* | 0.230* | 0.188* |
| **IM ratio** | 0.953 | 0.923 | 0.934 |

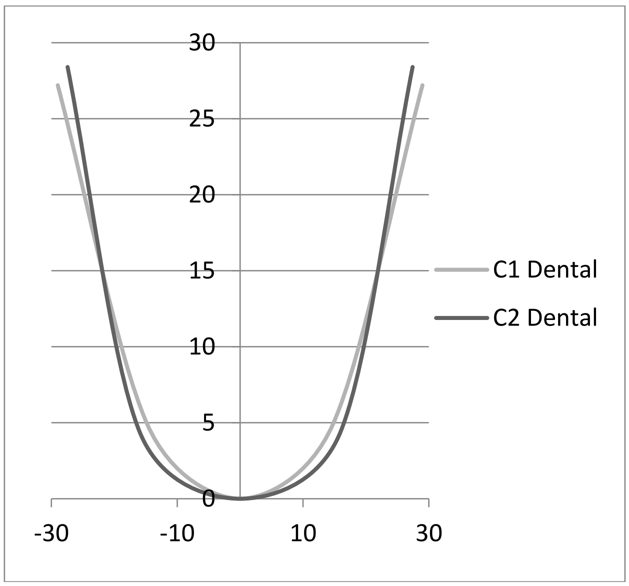


**Figure 1.** Best-fitting curve, the comparison of dental arch indexes in Class I and II patients

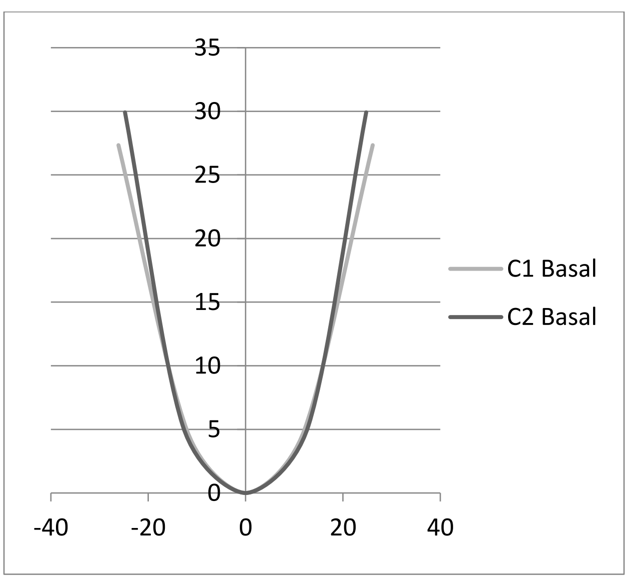


**Figure 2.** Best-fitting curve, the comparison of basal bone arch indexes in Class I and II patients

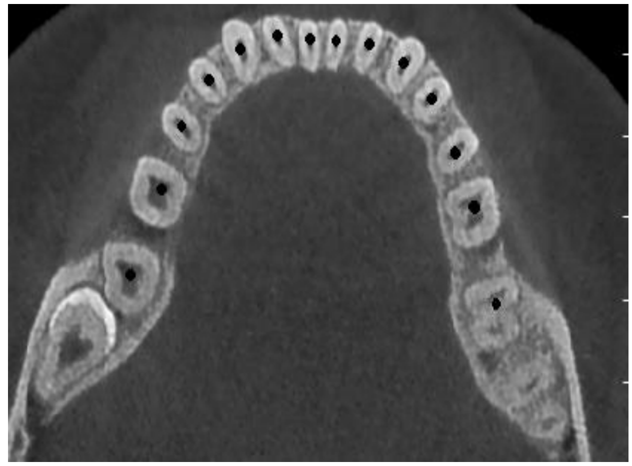

**Figure 3.** Digitized rendered view of CBCT scan, root center points

## DISCUSSION

The present cross-sectional analytical study assessed basal bone and dental arch indexes in Class I and II patients by using their CBCT radiographies. All samples were separately measured with respect to size and intended indexes. The results of this study can facilitate the attainment of treatment purposes and more sustainable outcomes in orthodontic treatments.

The formation of a dental arch, which is harmonized with inferior supporting basal bone, is considered as one of orthodontic treatment purposes. Based on previous studies, different methods with contradictory results were used to evaluate the relationship between the shape of dental and basal bone arches [1]. Determining basal bone indexes requires a precise definition of bone arch.

Lundstrom defined basal bone as horizontal plane in the apex region of teeth [3]. Howes considered the apical third of alveolus as landmark for basal bone [22]. Andrew used WALA ridge, a band of keratinized soft tissue under muco-gingival junction, as apical base [23].

Based on the results of several studies which focused on the shape of basal arch, using the landmarks related to alveolar bone is suggested and applying "basal arch" term is considered as wrong. However, the placement of basal or alveolar arch near tooth results in increasing its clinical importance compared to that of anatomic basal bone [22, 24-26].

Further, CT techniques are considered as authentic and beneficial methods for observing and assessing dental and bone indexes. Several advantages were reported for CBCT radiography technology compared to other diagnostic methods, including fast scanning, less image distortion due to patient movement, isotropic voxel resolution and accessibility to teeth [27]. By the emergence of CBCT, new landmarks, especially root center (RC point), were defined to evaluate basal arch in CBCT images. RC point is located in the anatomical structure of basal and regarded as the center of rotation (COR) of each tooth. The use of RC points instead of WALA points on a virtual model results in representing the changes of basal arch under the influence of orthodontic forces more precisely). Based on the previous studies, CBCT imaging is considered as a high precision tool for linear measurements especially compared to anatomic measurements [4]. Thus, root center as a transverse cut in the surface of the middle third of canine root was used as the landmark of basal bone in the present study (Fig. 3)

Although, the requirement to higher dose is regarded as the disadvantage of CBCT imaging compared to conventional radiographies, the present study indicated that effective dose in some CBCT devices is 3 times higher than panoramic dose [26, 28]. In fact, the advantages of CBCT and its radiation dose should be considered.

Gender separation issue was not highlighted in the present study since there was no difference between the indexes related to males and females in previous studies [5, 24].

Regarding sample unification, sagittal relationship (ANB and molar relationship) was used in previous studies [1, 5, 24]. while the unification of vertical dimension was added in the present study (Jaraback index).

Considering dental indexes, Gupta found no significant difference between the width of IC and IM in Class I patients, which is inconsistent with the results of the present study. Further, IC width related to children was significantly higher than that in adults in Class II, while IC width was obtained 2mm in the present study, which is clinically regarded as significant, and is not in line with that of Gupta. Furthermore, a significant difference between dental and bone molar width was observed in the present study, which is in inconsistent with that of Gupta due to applying different methods and using 3D computer method in the present study. The effect of age in basal bone and dental development can be specified since patients with different age participated in these two studies [1].

Regarding the dimensions of dental arch in different malocclusion, Slaj et al. reported that the depth and width of IC and IM in patients with Class I malocclusion were higher compared to those having Class II malocclusion, which is not in line with those in the present study due to the selection of different landmarks or samples from different ethnicity [29]. Based on the study of Ball, the dental arch indexes of IC and IM width in Class II patients were greater than those in Class I ones, which IC and IM index are consistent and inconsistent with those in the present study, respectively [24].

Braun et al. reported that the dental arch indexes of the width and depth of IM and IC in Class II malocclusion was obtained lower than those in Class I. This difference was related to the presence of compensating mechanism in Class II samples [30]. As Gupta maintained, the basal bone index of IC width in Class I was attained higher than that in Class II and IM width related to Class II was greater compared to that in Class I, which is in the line with the present study due to the simultaneous participation of adults and children in the present study [1]. Based on the study result of Ball, the basal bone index of IC width in Class II patients was obtained higher compared to that in Class I ones, which is consistent with that in the present study. Further, IM index in Class I patients was determined greater than that in Class II ones, which is in agreement with that in the present study [24].

In addition, a strong correlation was observed between the dental and bone indexes of IM ratio, IM depth, IM width and IC width, as well as a moderate correlation between the dental and bone index of IC depth in both Classes of I and II. The results could confirm the study of Suk [5] in Class I and those of Gupta [1], Ball [24] and Ronay [25] which used dental casts for assessing indexes. However, no correlation was reported between IC and IM depth in normal occlusion in the study of Bayome [28]. The presence of different occlusions in the group under study leads to different results. Comparing best-fitting curves indicates that basal arch form related to Class I in molar region is wider than that of Class II, which is consistent with the study result of Salj [29].

Based on the results of the previous studies, assessing patients with different age results in obtaining different dental and bone dimensions in different malocclusion. For example, some studies represented that IM width in Class II children was higher than that the amount in adults [1, 31].

Determining the dimensions and shape of dental and basal arches and their interactions could help clinicians to position teeth precisely during treatment and maintain the arch form of patients, leading to more sustainable and predictable treatment results. The present study can help clinicians to understand the relationship between basal and dental arch in Class I and II better. The treatment is considered as questionable by disregarding the relationship between basal and dental arch.

Most of the previous studies were conducted by relying on dental casts and virtual 3D models [1, 24, 32, 33]. Regarding the results of the present study, the preparation of casts and 3D models is considered as impossible due to its cross-sectional nature and using available archive data. It is suggested that future studies should be conducted by combining the data derived from 3D models and CBCT imaging due to the high precision of CBCT imaging. In addition, further studies can focus on finding other landmarks instead of RC point in order to assess basal bone more precisely.

## Conclusion

Based on the results, regarding dental indexes, IC width, IM depth and IC ratio in Class II patients were determined higher compared to those in Class I ones, while IM ratio in Class I patients was obtained greater than that in Class II ones. In addition, considering basal arch indexes, the higher width and ratio of IM was observed in Class I patients and greater IM depth was achieved in Class II ones. Further, the transverse dental and basal indexes are consistent, along with a difference in IC depth. Finally, there is a strong correlation between the dental and bone indexes of IM ratio, IM depth, IM width and IC width, as well as a moderate correlation in the dental and bone indexes of IC depth.

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