ABSTRACT

Objectives: A study was conducted to assess the contribution of the cancellous and endosteal surface of the cortical bone to the trabecular pattern seen in an IOPA radiograph.

Materials and methods: An in vitro study analyzing the contribution of the endosteal surface of cortical bone and cancellous bone to the trabecular pattern was conducted, using 60 specimens of desiccated human mandibles. The mode of execution involved IOPA radiographic evaluation of premolar segments in the specimens before and after removal of cancellous bone. The radiographs were numbered for identification and subjected to evaluation by 5 dentomaxillofacial radiologists who were doubleblinded to ensure an unbiased interpretation.

Results: The trabecular pattern appreciation by the experts in the IOPA radiographs before and after removal of cancellous bone displayed immaculate correlation as per the Goodman-Kruskal Gamma Coefficient values which was 0.78 indicating a very large correlation. The relative density of trabecular pattern was significantly higher in radiograph before than after removal of cancellous bone with p-value less than 0.05.

Conclusion: Based on these results it was adjudged that both the cancellous and endosteal surface of cortical bone contributed significantly to the trabecular pattern in an IOPA radiograph.

Keywords: Extension cone projection (XCP), Orthopantamogram (OPG), Intraoral periapical (IOPA), Personal protective equipments (PPEs).


Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

The composition of bone in the human body can be described as either cortical or cancellous. The term cortical is derived from the Latin word cortex which means, ‘outer layer’. Cortical bone also described as compact bone, is the dense outer layer of bone. The term cancellous means a criss-cross lattice arrangement of interlacing plates or bars. Histologically, trabeculae may be cylindrical, rod shaped, wide uneven irregular sheets of bone, twisted plates, spongy tubes and parallel striations. Breseia classifies them into regular horizontal type and irregular type. The regular type is less common and is load bearing. It is significant to realize that the trabeculae are just bridges of bone connecting the cortical plates and that they do not meet one another. They are well spaced in a three-dimensional lattice, despite this feature it is poorly simulated in a two-dimensional radiograph and the trabeculae appear as branching patterns. Consequently, there is more branching of trabeculae in a radiograph, but it does not necessarily represent itself as an increase in density. The radiographic appearance of bone striae is classically thought to reflect the trabecular pattern of cancellous bone.

Bender proposed that the radiographic appearance of trabecular pattern is contributed by the endosteal surface of the cortical bone, a philosophy that challenged conventional ideas. The term junctional area (endosteal surface) refers to that region of the bone in which small marrow cavities are visible on cross-section, immediately adjacent to the dense cortical bone and do not contain medullary cavities. Michel K Shrout et al and Scott Jett et al also contravened the traditional belief by deducing that the appearance of trabeculae is a result of contribution of both the cancellous and endosteal surface of cortical bone.

The purpose of this study is to investigate the source of radiographic trabecular patterns in the mandible. In this in vitro cross-sectional study 60 mandibular sections were taken to resolve the source/origin of the architectural image attributed to bone on conventional radiographic images and to discover the anatomical location of the structures interpreted as trabeculae.

MATERIALS AND METHODS

For this study thirty-two desiccated mandibles were collected from the district mortuary after obtaining the appropriate approval from the respective authorities and ethical committee members. The entire procedure is summarized as below:

Preparation and Selection of Specimens

The mandibles were cleaned and dried thoroughly free of debris and residue. The surface was scrutinized for defects that might be of radiological significance. After cleaning, the mandibles were disinfected using a nonradiopaque disinfectant (40% formalin) with PPEs (personal protective
equipment). Further, the disinfection procedure was carried out in a well-ventilated room to avoid respiratory burns.

Panoramic radiographs of specimens were obtained after standardization, to rule out osseous deformities and other osteolytic lesions. This was accomplished by fabricating a support stand that would fit snugly into the chin positioner of the panoramic machine (Fig. 1). The chin positioner along with the custom-fabricated support stand served to position the mandible in a standard position from the source point. Radiographs of all the specimens were taken at 3 mA and 65 kVp, and processed under standardized conditions. Subsequently, the radiographs were evaluated and 30 appropriate specimens were selected. Two specimens which showed osteolytic lesions in the area of interest were discarded. Selected specimens were numbered for further study.

**Isolating the Area of Interest**

The specimens were sectioned and mental foramen was used as a landmark to determine the area of interest (Fig. 2). The area of significance was marked using a nonradiopaque marker by drawing two vertical lines at a distance of 15 mm, on either side of the mental foramen. The marked areas of the specimens were cut using a carborundum disk using intermittent strokes and water spray to prevent overheating.

**Obtaining Radiographs before Removal of Cancellous Bone**

The separated segments were radiographed using IOPA standard size 2 E speed films (Kodak). Special elastic guards were used to stabilize the specimens. The XCP film holder was adjusted so that the distance between the source of the X-ray beam and that of the film was 39 cm (Fig. 3). The exposure was standardized at 0.7 seconds, with 65 kVp and 8 mA. These radiographs were numbered from 1A to 60 A, tagged and processed in an automatic processor with standardized solutions.

**Sectioning of Specimens**

The candid specimens were sectioned using the same armamentarium. Sectioning was done mesiodistally from apex downward to split the buccal and lingual cortical plates of the specimen. Finally, the cross-sectioned split specimens were of equal size and the split extended through the long axis (Fig. 4).

**Detaching the Cancellous Portion of the Bone**

The cancellous bone (medullary bone) attached to the cortical plates was removed meticulously to guard the endosteal surface of cortical bone. The cancellous-cortical junction (see Fig. 4) had to be preserved to evaluate its contribution to the trabecular appearance in the radiograph. A vulcanite trimmer was used in a low speed high torque micromotor to avoid overheating. A three-way syringe was used intermittently to wash the site free of dust. PPEs were

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**Fig. 1:** Panoramic machine—trophy assembled with desiccated human mandible

**Fig. 2:** Desiccated human mandible, isolated and sectioned segments

**Fig. 3:** X-ray machine—confident assembled with XCP—Dentsply and bone segment
used as directed by the standard protocol. After removing the cancellous bone, the cortical plates with its intact endosteal surface were safeguarded to the next procedure.

**Reassembly and IOPA Recording**

After removal of the cancellous portion, the cortical plates of the same segment were reassembled to the original anatomic position and stabilized using sticky wax (see Fig. 3). The reassembled segments were radiographed with IOPA films using the same procedure. These radiographs were also given numbers ranging from 1B to 60B to correspond with the numbers given to the radiographs of the intact segments prior to removal of the cancellous portion.

**Comparative Qualitative Evaluation**

The IOPA radiographs were separately evaluated by Dentomaxillofacial radiologists with more than 7 years of experience. The experts were blinded to the nature of the study. Groups A and B radiographs were correctly paired but randomly arranged in the pair to avoid bias (Fig. 5). The panel’s interpretation was recorded in a preformatted qualitative evaluation questionnaire separately by each specialist. The results were subjected to statistical analysis.

**RESULTS**

The data obtained from the five dentomaxillofacial radiologists were tabulated in a master chart to compare the visibility of trabeculae in both before (A) and after the removal of cancellous bone (B). The chart also included information regarding the comparative density between the test specimens.

The overall correlation for the appreciation of trabecular pattern in radiographic specimens between the specialists was 0.78, which can be deduced as very large correlation, as per Goodman-Kruskal gamma coefficient.

The interpretations of the relative density between the radiographic specimens were analyzed by tabulating the values in Table 1 and Graph 1A. Pearson’s correlation coefficient was used to analyze the variation in the density observed in all the specimens by all the five experts, and the results were considered to be significant at 5% level, if the p-values was ≤0.05, and highly significant at 1 and 0.1% if the p-value was ≤0.001 and ≤0.0001 respectively.

Based on the above values, it can be inferred that the variation in density of the trabecular pattern observed by all the experts are significantly higher (<0.05) in group A than group B.

**DISCUSSION**

Traditionally, it was believed that the radiographic appearance of trabeculae was due to the presence of cancellous bone.¹ ³ ⁸ ⁹ However, Bender ignited a controversy claiming that the trabecular appearance was due to corrugations in the endosteal surface of the cortical plate, where the cancellous bone fused with cortical plate. More researchers supported Bender hypothesis.⁴ Yet, most of the studies failed to validate their results with a statistically significant group of specimens.

This study was conducted with an aim to address these shortfalls and to arrive at a conclusion as to the origin of trabeculae in an IOPA radiograph. Statistical analysis of the data obtained from this study divulged that in 267 of 300 events the trabeculae were appreciated even after removal of the cancellous bone, with an overall correlation pattern appreciation of 0.78 (Table 2, Pie Chart 1 and Graph 1B). Out of these 5 experts, 2 of them showed 100% recognition, i.e. they supported the presence of trabeculae in all the 60 specimens (see Table 2 and Graph 1B). This inference unquestionably suggests that cortical bone has a significant contribution to the formation of trabeculae in a radiograph.

Density of trabecular pattern prior to the removal of cancellous bone is significantly higher in-group A with a p-value less than 0.05 than group B (Table 1 and
Graph 1A). Hence, the cancellous bone significantly contributes toward the trabecular pattern in IOPA radiograph. A study, in which controlled bony lesions were produced in cadaveric long bones and standardized sequential radiographs after the various stages, concluded that radiographic changes in the trabecular pattern occurred when the transitional (junctional) area from cortical to a cancellous bone was involved in the lesions,\(^5\) which supports this study.

Bender has explained that if the mineral content per unit volume of the tissue is low, for instance in cancellous bone, a large volume of tissue needs to be destroyed, before radiographic changes can be seen.\(^10\) In this study in spite of removing the entire cancellous bone present between two cortical plates of the segments, the experts appreciated the trabeculae. This implies that the endosteal surface of the cortical bone and junctional trabeculae also contribute to the radiographic image of the trabeculae. This finding is in coherence with the results of similar studies conducted previously.\(^4,5,10-13\)

This study supports that both cancellous and cortical bones contribute to the formation of trabecular pattern in a roentgenogram. However, it should be recognized that invisible trabecular lesions still pose a great challenge to oral radiologists, and that a two-dimensional radiograph is a poor diagnostic tool for assessing bone quality.

ACKNOWLEDGMENT

I express the feeling of pride of my greatest asset, ‘My Father, Mother, Brother, Wife, Daughter and

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Inference: Density of trabecular pattern is significantly higher in radiograph A when compared to radiograph B.
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REFERENCES


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