Dense Bone Islands in Orthodontic Patients:
A Cross-sectional Imaging (CBCT) Study of Location and Interactions with Teeth

A Thesis

SUBMITTED TO THE FACULTY

OF THE UNIVERSITY OF MINNESOTA

BY

Nathaniel Maxwell Caple, DDS

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE

Advisor: Mansur Ahmad, BDS, PhD

June, 2024

Acknowledgements

I would like to express my sincere appreciation to Dr. Mansur Ahmad for his unwavering guidance and mentorship throughout this project.

I wish also to thank the orthodontic faculty, staff, and orthodontic residents at the University of Minnesota for their invaluable support and assistance.

Dedication

I dedicate this work to my parents, Ann and John, who have supported me without hesitation in all of my professional and personal pursuits. There were many falls along the way and they were always there to help get me back on my feet.

Abstract

Aim: To use CBCT imaging taken before and after orthodontic treatment to evaluate the interactions between dense bone island (DBI) lesions and teeth. Specific aims were to evaluate 1) where dense bone islands reside in the buccal-lingual dimension of the jaw bones, 2) if DBIs tend to occur in areas of potential orthodontic tooth movement, 3) presence of root resorption on teeth adjacent to DBIs, and 4) presence of hindered orthodontic tooth movement of teeth adjacent to DBIs.

Methods: This project reviewed 2243 CBCT radiology reports on patients undergoing treatment at the University of Minnesota Graduate Orthodontics Program between the years of 2018 and 2022. Patients were included in this study if at least one of their CBCT radiology reports contained one of the following words: dense bone island, idiopathic osteosclerosis, or enostosis. For the 87 dense bone islands included in the study, the pre- and post-orthodontic CBCT images were analyzed using the linear measurement tool in Dolphin Software to identify changes to the dense bone islands and adjacent teeth over time. Information related to dense bone island location, shape, size, evidence of root resorption, evidence of hindered root movement, and the patient demographics were recorded. Prevalence of root resorption and root movement hindrance and prevalence of DBIs in various buccal-lingual locations were reported.

Results:

Of the 87 DBIs included in the study, 65 of them (74.7%) were deemed to be located in areas of potential orthodontic tooth movement. Of the 65 DBIs located in areas of potential orthodontic tooth movement, 8 of them (12.3%) showed evidence of root resorption and 6 of them (9.2%) exhibited signs of hindered tooth movement.

In the post-orthodontic scans, 39.1% of the DBIs were connected to the lingual plate alone, 31.0% of the DBIs were bi-cortical, 17.2% were connected to the buccal plate alone, and 12.6% were intracortical without evidence of contact with either cortical plate.

Table of Contents

List of Tables

List of Figures

Review of the Literature

Radiopaque entities are frequently observed in the jaw bones. Some conditions represent pathosis, e.g., sclerosing (condensing) osteitis, periapical cemento-osseous dysplasia, and cementoblastoma, A frequently encountered condition is a dense bone island (DBI), an idiopathic phenomenon. This condition is known by several other names, including idiopathic osteosclerosis, bone whorl, bone scar, enostosis, bone eburnation, and focal periapical osteopetrosis. [1,2] The DBI are considered a variation of normal development analogous to a palatal or lingual torus. [5]

Several studies have assessed the frequency, size, and location of DBI in the maxillomandibular area among various populations. [2,6–12] These radiopacities have an incidence between 1.5% and 11.8% of the studied populations, although some races such as Chinese, Africans, Japanese, and Indo-Chinese appear to have higher prevalence. [2,6–12] Some studies have found a higher incidence of DBI in women, [1,6,8,13] although the majority of studies show differences between the sexes to be insignificant. On radiographic examination, DBIs are generally localized, well-defined, mixed or uniformly radiopaque, non-expansile, small (2-3mm), and have a strong predilection for the mandibular premolar and molar areas. [2] Occasionally, dense bone islands greater than 2.5cm are found in the jaws. [12,14]

Few longitudinal studies have been conducted to identify how DBIs change in frequency and size over time, but the data suggest that the entities are very rare in the first decade of life. [2] During the second and third decades of life, the DBIs are most common and are susceptible to growth and increased radiopacity.[9,15,16] Furthermore, the development of new DBIs and change of the existing mass is uncommon after the fourth decade of life. [12,17] These observations suggest that DBIs are a variation of normal osseous development during bone maturation and remain mostly stable after growth is completed. [1,12,15,18]

The non-expansile nature of dense bone islands may lead dentists to regard DBIs merely as an incidental finding that has little impact on dental treatment planning. Generally, no treatment is recommended for these conditions. Some studies have recommended only radiographic monitoring.[19,20] Nonetheless, special consideration may be required in the case of DBIs in close proximity to the roots of teeth, especially for orthodontists whose treatment plans involve moving these teeth. Some studies have found that DBIs do not hinder tooth movement or cause external root resorption, [17] whereas other studies have reported DBIs to cause self-limiting external root resorption of teeth[3,16,21–24] and hindered tooth movement.[21,22,25] These findings have led some researchers to recommend caution when planning tooth movement in the area of tooth movement,[26] or to use a temporary anchorage device (TAD) to aid in space closure adjacent to a sclerotic bony mass.[27]

One possible reason for the lack of consensus regarding the effect of DBIs on teeth may be the lack of longitudinal three-dimensional radiographic data on patients undergoing orthodontic treatment. The vast majority of radiologic DBI research utilized only panoramic radiography to identify and characterize lesions. Few have used cone beam computed tomography (CBCT) images to perform three-dimensional analysis of DBI shape, size, and location.[22,28] A search on PubMed did not reveal any studies using three-dimensional radiographic data analyzed over multiple time points on teeth undergoing orthodontic tooth movement to characterize the 3D location of DBIs, their changes over time, and their interactions with teeth during orthodontic treatment.

This study seeks to augment the existing understanding of DBIs by bolstering the three-dimensional understanding of DBIs, particularly regarding potential interactions between teeth and DBIs during orthodontic tooth movement. This information could prove invaluable to radiologists making comprehensive radiology reports as well as help orthodontists make decisions about tooth movement adjacent to DBIs.

Aims

The general aim of this study was to use CBCT scans to evaluate the impact of dense bone islands on teeth undergoing orthodontic tooth movement.

The specific aims of the study were:

1. To determine the buccal/lingual location of dense bone islands in our study population.
2. To determine if DBIs occur in areas of potential orthodontic tooth movement.
3. To determine if dense bone islands (DBIs) are associated with root resorption of adjacent teeth.
4. To determine if dense bone islands hinder root movement during orthodontic treatment.

In addition to the aims listed above, information was also collected and reported on regarding the following: age and sex of patients in sample, associations of DBIs with midpalatal and lingual tori, DBI bone quality, DBI shape, DBI size, DBI location in the jaws, DBI location relative to adjacent teeth

Null Hypotheses

1. There is no difference in the prevalence of DBI lesions associated with the buccal cortical plate, the lingual cortical plate, both cortical plates, and neither cortical plate.
2. DBIs will not be found in areas of “potential orthodontic tooth movement” as defined as areas more occlusal than root tips and extending into the middle 1/3 of the alveolus from a bucco-lingual dimension.
3. There is no difference in the prevalence of root resorption between teeth in close proximity (within 1mm) of a DBI and teeth not in close proximity to a DBI.
4. There is no difference in the root parallelism between teeth in close proximity (within 1mm) of a DBI and contralateral teeth not in close proximity to a DBI.

Methods

This survey included a review of a total of 2243 Oral and Maxillofacial Radiology reports conducted on patients undergoing treatment at the University of Minnesota Graduate Orthodontics Program between the years of 2018 and 2022. As part of orthodontic treatment in this program, all patients obtained a pre- and post-treatment CBCT encompassing the entire maxillomandibular region. Every Cone Beam Computed Tomography (CBCT) scan was read by a single board certified Oral and Maxillofacial Radiologist. Patients were included in this study if at least one of their CBCT radiology reports used one of the following words: dense bone island (DBI), idiopathic osteosclerosis, or enostosis. Once these patients were identified, the pre-orthodontic and post-orthodontic CBCT images were analyzed to identify changes to the dense bone islands and adjacent teeth over time. A total of 87 DBIs from 79 patients met the criteria for inclusion in this study and the corresponding 158 CBCT images (2 for each DBI) were analyzed. Eight of the patients had two DBIs and these were included in the analysis.

Aim 1: Each DBI was be categorized based on its association with a) the buccal cortical plate, b) the lingual cortical plate, c) both cortical plates, or d) neither of the cortical plates. The prevalence of each location was reported.

Aim 2: Each DBI was evaluated as occurring or not occurring in an area of "potential orthodontic tooth movement." For this study, if an interradicular- or apically-positioned lesion extended into the jawbone more than 1/3 of the total buccolingual distance, it was presumed to be capable of interaction with a tooth during orthodontic movement. This result was given as a simple percentage of total DBIs as a reference for how likely orthodontists are to encounter DBIs that might warrant consideration during orthodontic treatment planning.

Aim 3: The length of teeth in close proximity to a DBI lesion (within 1mm as measured with the Dolphin measuring tool on the three-dimensional CBCT rendering) were compared between the pre-orthodontic and post-orthodontic CBCT to identify root shortening. To rule out the possibility that root shortening was caused by orthodontic tooth movement alone, teeth exhibiting root resorption were compared against the contralateral tooth for evidence of root resorption associated with the DBI at least 1.0mm in excess of that experienced by the contralateral tooth. The prevalence of root resorption was reported.

Aim 4: Teeth in close proximity to a DBI lesion (within 1mm) were compared against adjacent teeth for root parallelism. When roots of the DBI-adjacent tooth deviated by more than 10 degrees from the adjacent roots in either a buccal-lingual or mesial-distal direction, hindrance of tooth movement was assumed. This was the most reasonable approach even though it did not eliminate the possible confounding variables that could also lead to a lack of root parallelism (i.e. improper bracket placement or intentional avoidance of a DBI leading to a lack of root parallelism).

In congruence with the diagnostic criteria used by previous studies, dense bone island entities were identified as asymptomatic, well-defined, non-expansile, radiopaque entities of the maxillomandibular region that could not be attributed to any pathosis.

In order to exclude lesions with similar radiographic findings, the following criteria proposed by Geist and Katz[1] were used for exclusion in the survey.

1. Periapical lesions around teeth with deep caries or large restorations.
2. Mixed radiopaque-radiolucent areas characteristic of periapical cemental dysplasia and other benign fibro-osseous lesions of periodontal origin.
3. Increased thickening of the lamina dura around teeth that showed marked malposition or that served as abutments for fixed bridges or partial dentures.
4. Clearly identifiable remnants of deciduous or permanent teeth.
5. Radiopacities interpreted as tori or exostoses.
6. Solitary radiopacities in edentulous regions that might represent residual sclerosing (condensing) osteitis.

Radiopaque areas that met these criteria were categorized based on the following location classifications proposed by Geist and Katz.[1]

1. Interradicular: limited to the area between the roots
2. Interradicular and separate: located coronal to the root apex but clearly separated from the adjacent roots
3. Apical and interradicular: at the apices and exhibited significant extension between the roots
4. Apical: predominantly located around the root apices
5. Apical and Separate: apical and clearly separated from teeth and lamina dura

Furthermore, with the additional of three-dimensional data from the CBCT scans, DBIs were categorized based on their buccolingual positioning in the jaw as follows:

A. Buccal: DBI in contact only the buccal/facial cortical plate
B. Lingual: DBI in contact only the lingual/palatal cortical plate
C. Intra-cortical: DBI located completely in trabecular bone and not in contact with cortical bone
D. Bicortical: DBI extending across and in contact with both cortical plates

Information related to DBI location, shape, size, bone quality, evidence of root resorption, evidence of hindered root movement, the patient's age and sex, as well as the prevalence of midpalatal and lingual tori were recorded for analysis. In accordance with previous recommendations,[1] medical histories were examined for disease of the kidneys, parathyroid glands, and gastrointestinal tracts, which might affect bone metabolism.

Data regarding changes in DBI size were analyzed using the linear mixed effect model. All other data were reported using descriptive statistics to identify the frequency of different DBI locations and their interactions with adjacent teeth.

Results

Demographics

Our sample consisted of 87 DBIs from a total of 79 individuals. Of those individuals with DBIs, 50 were female and 29 were male. The median age of individuals included in the study was 17 years at the time of the pre-orthodontic CBCT and 21 years old at the time of the post-orthodontic CBCT. The ages of subjects before orthodontic treatment ranged from 7 years old to 66 years old.

Midpalatal and Lingual Tori Associations

The majority of patients with DBIs did not have a midpalatal torus or lingual tori. Only 6 (6.9%) of the subjects presented with a midpalatal torus. Lingual tori were present in 18 (20.7%) of the subjects.

DBI Bone Quality

Most of the DBIs had a radiographically uniform appearance and were deemed “uniformly radiopaque” (89.7%) as opposed to having “mixed radiopacity” (10.3%) at the final CBCT. Between the initial CBCT and final CBCT, there were only three DBIs that changed in their bone quality and changed from mixed radiopacity to uniform radiopacity over time. Of these three DBIs that changed density, two of them were located in the same patient and changed from age 15 to age 19. The third DBI that changed density was in a patient and the density change occurred from age 16 to age 18.

DBI Shape

When seen in the reconstructed panoramic views of the pre-orthodontic CBCT, there was a similar proportion of DBIs with round (42.0%), oval (35.8%), and irregular (22.2%) shape. The proportions were similar in the post-orthodontic panoramic view, with 37.9% round, 34.5% oval, and 27.6% irregular. There were six DBIs that changed in shape from the pre- to the post-orthodontic CBCT. Of these six DBIs that changed shape, two changed from round to irregular, two changed from oval to irregular, one changed from irregular to round, and one changed from round to oval.

When seen from a cross-sectional view in the pre-orthodontic CBCT, there was a similar proportion of DBIs with round (38.3%), oval (33.3%), and irregular (28.4%). The proportions were similar in the post-orthodontic cross-sectional slice with 33.3% round, 33.3% oval, and 33.3% irregular. There were nine DBIs that changed shape from the initial scan to the final scan. Three DBIs changed from oval to irregular, two changed from round to oval, two changed from round to irregular, one changed from oval to round, and one changed from irregular to round.

DBI Size

On average, DBIs increased in size over time. The mesio-distal width (Table 1) increased by 0.732 mm ($p<0.05$), the vertical dimension (Table 2) by 1.029 mm ($p<0.05$), and the bucco-lingual width (Table 3) by 0.413 mm ($p<0.05$).

Table 1: DBI maximum mesial-distal width: Pre-orthodontic vs post-orthodontic size using Linear Mixed Effect Model

	Difference estimate*	p-value
Overall (N=87)	0.732	0.005
Initial age 7~13 years (N=24)	2.354	0.001
Initial age 14~17 years (N=20)	0.350	0.326
Initial age 18~26 years (N=24)	0.171	0.748
Initial age 27 years+ (N=19)	-0.205	0.139

Table 2: DBI maximum vertical dimension: Pre-orthodontic vs post-orthodontic size using Linear Mixed Effect Model

	Difference estimate*	p-value
Overall (N=87)	1.029	0.006
Initial age 7~13 years (N=24)	2.950	0.012
Initial age 14~17 years (N=20)	0.675	0.178
Initial age 18~26 years (N=24)	0.167	0.765
Initial age 27 years+ (N=19)	0.063	0.702

Table 3: DBI maximum buccal-lingual width: Pre-orthodontic vs post-orthodontic size using Linear Mixed Effect Model

	Difference estimate*	p-value
Overall (N=87)	0.413	0.030
Initial age 7~13 years (N=24)	1.471	0.008
Initial age 14~17 years (N=20)	-0.010	0.960
Initial age 18~26 years (N=24)	0.121	0.728
Initial age 27 years+ (N=19)	-0.111	0.529

To identify size changes of the DBIs, the patients were divided into four age groups: 7 to 13 years, 14 to 17 years, 18 to 26 years, and 27+ years. These groupings were made primarily to allow for similar numbers of subjects included in each group. In addition, the groupings are logical from a developmental standpoint, with the 7-13 year-olds belonging to a preadolescent group, the 14-17 ages being the adolescent group, the 18-26 ages being the young adult group and the 27 and older individuals being the adult group.

The DBI changes over time were only significant for the 7-13 age group. For the 7-13 age group, DBI mesial-distal width grew by 2.35 mm ($p<0.05$), vertical dimension grew by 2.95 mm ($p<0.05$), and bucco-lingual depth grew by 1.47 mm ($p<0.05$). For the 14-17 age group, DBI width grew by 0.350 mm, vertical dimension grew by 0.675mm, and depth shrank by 0.010mm. For the 18-26 age group, DBI mesial-distal width grew by 0.17mm, vertical dimension grew by 0.167mm, and depth grew by 0.121mm. For the 27 and older group, DBI width shrank by 0.205mm, height grew by 0.063mm, and width shrank by 0.111mm.

There were six DBIs that had not yet formed in the initial scan but were present in the final scan. For these DBIs, the patients were aged 9, 12, 13, 14, 16, and 17 years old. These six DBIs experienced more growth than the DBIs that were present at the initial scan and increased the average DBI growth for the 7-13 age group and the 14-17 age group. When these data points were excluded so that only DBIs present at both the initial and final scan were included, the DBI size changes are as follows.

When the data points were excluded for the DBIs that had not yet formed in the initial scan, there was only one age group and one dimension that changed significantly from the pre-orthodontic scan to the post-orthodontic scan. Namely, for the 7-13 age group, DBI width grew by 1.11mm ($p<0.05$). DBIs from no other groups experienced significant size changes over time.

Inferior Alveolar Canals and DBIs

DBIs were frequently located adjacent to and attached to the cortical housing of the inferior alveolar canal. 52.9% of the DBIs in the post-orthodontic CBCT were positionally connected to the IAC.

DBI Location

Location in Jaws:

A vast majority of the DBIs in this sample were located in the mandible (94.3%) than in the maxilla (5.7%). The most common location for a DBI was the mandibular premolar area (42.5%), followed closely by the mandibular molar area (41.4%). The mandibular anterior region contained 10.3% of the DBIs. The least common areas for DBIs were the maxillary premolar region (3.4%), the maxillary molar region (2.3%), and the maxillary anterior region (0%).

Table 4: Prevalence of DBIs in different locations in the jaws

	N	Mn Anterior, n (%)	Mn Molar, n (%)	Mn Premolar, n (%)	Mx Molar, n (%)	Mx Premolar, n (%)
Location in jaws	87	9 (10.3)	36 (41.4)	37 (42.5)	2 (2.3)	3 (3.4)

Location Relative to Adjacent Teeth:

DBIs were located primarily in the “apical” tooth region (58.0% for the pre-orthodontic CBCT and 55.2% for the post-orthodontic CBCT). The second most common location was “apical and separate” (16.0% in the pre-orthodontic CBCT and 21.8% in the post-orthodontic CBCT). The third most common location was “apical and interradicular” (12.3% in the pre-orthodontic CBCT and 11.5% in the post-orthodontic CBCT). The least common locations were the “interradicular” and the ”interradicular and separate” areas.

There were nine DBIs that changed locations from the initial to the final CBCT. Four changed from “apical” to “apical and separate”, one changed from “apical and interradicular” to “apical and separate”, one changed from “apical and separate” to “apical,” one changed from “interradicular and separate” to “apical,” and two changed from “interradicular and separate” to “interradicular”. The initial ages of the patients with DBIs that changed location were 9,13,14(n=3), 23, 26, 56, and 59 years old. All DBIs that changed location, except for one, were located in the mandible.

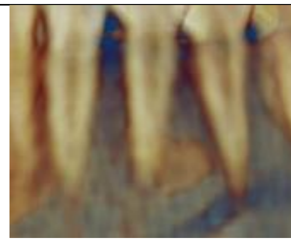
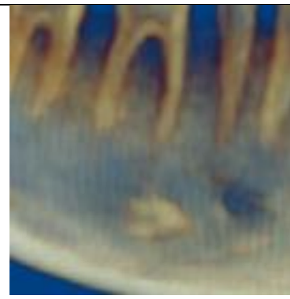
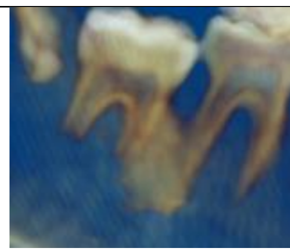
Apical (55.2%)	
Apical and separate (21.8%)	
Apical and interradicular (11.5%)	
Interradicular (8%)	
Interradicular and separate (3.4%)	

Figure 1: CBCT examples of locations of DBIs relative to adjacent teeth and their prevalence

Cross-sectional Location (Aim #1):

There was a tendency for DBIs to be associated with the lingual plate. 39.1% of the DBIs in the post-orthodontic scan were connected to the lingual plate alone. The second most common cross-sectional location was for DBIs spanning across the alveolus and connected to both the buccal and lingual plates (31.0%). Less commonly, DBIs were associated only with the buccal plate (17.2%). The least common cross-sectional location was with DBIs existing between but touching neither the buccal plate nor the lingual plate (12.6%).

Lingual cortical plate only (39.1%)	**Both buccal and lingual cortical plates (31%)**	**Buccal cortical plate only (17.2%)**	**Between buccal and lingual cortical plates (12.6%)**
			

Figure 2: CBCT examples of cross-sectional DBI locations and their prevalence

Location in an area of potential tooth movement (Aim #2):

One of the core questions of this study was whether or not DBIs tend to be located in areas of potential orthodontic tooth movement. We defined areas of potential tooth movement as DBIs extending at least 1/3 of the bucco-lingual distance into the alveolus as well as occurring vertically in the alveolus such that translation of an adjacent tooth could make contact with the DBI (apical or interradicular area). Using these criteria, the majority of DBIs were located in areas of tooth movement. 74.7% of the DBIs at the post-orthodontic scan were located in an area of theoretical tooth movement.

DBIs and Root Resorption (Aim #3)

Root resorption was found in 12.3% of the teeth that were located adjacent to DBIs in areas of potential tooth movement. Of the 87 DBIs included in the study, 65 of them were deemed to be located in areas of possible tooth movement. Of those 65 DBIs, 8 of them (12.3%) showed contact with an adjacent tooth and a least 1mm more root resorption on the contacted root than on the contralateral root.

DBIs and Hindered Root Movement (Aim #4)

In some cases, DBIs were associated with the appearance of impeded tooth movement. Of the 65 DBIs located in areas of potential tooth movement, 9.2% of them exhibited signs of impeded tooth movement. As expected, apical DBIs, which were not in contact with the roots had no effect on tooth movement.

Discussion

Several studies have reported the prevalence and location of dense bone islands in various populations, but there remains a paucity of information regarding the three-dimensional location of DBIs using CBCT data. Furthermore, no studies have used CBCT scans pre- and post-orthodontic treatment to identify interactions between DBIs and teeth. This retrospective study leveraged the vast amount of CBCT data collected as part of orthodontic treatment at the University of Minnesota School of Dentistry Orthodontics Graduate Clinic to identify the longitudinal characteristics of DBIs and their interactions with teeth.

Demographics:

The subjects in this study ranged in age from 7 to 68 years old but mainly consisted of adolescents and young adults. Of the 79 patients included in this study, 50 (63%) were female. Although we reported on age and gender in this study, we do not intend to draw conclusions from this data since these demographic data points were not retrieved from the full set of 2243 radiology reports from which our patient subsection was derived.

Association with Midpalatal torus, Lingual tori, and Nerve canals:

There were 87 total DBIs included in the study. 6.9% of the DBIs were found in patients who also had a midpalatal torus. Midpalatal torus prevalence has been reported in previous studies to range from 3-60% depending on ethnicity,[29] so our study sample was within this large range. It would be difficult to conclude that there was an association between dense bone islands and midpalatal tori in our study population.

20.7% of DBIs were found in patients who also had lingual tori. Previous research has shown a large range of 0-80% in lingual tori prevalence depending on ethnicity.[30] It would be difficult to conclude an association between dense bone islands and lingual tori with this data. Future studies could be conducted using a control group to further evaluate this potential association.

In this study, DBIs were commonly associated with the cortical sheath of the inferior alveolar canal. In the post-orthodontic scan, 46 of the DBIs (52.9%) were touching the cortical sheath of the Inferior Alveolar Canal.

Location of DBIs in Jaws:

Previous studies found DBIs to have a strong predilection for the mandible over the maxilla[2,6–12], and our data show the same, with 94.3% of the reported DBIs residing in the mandible. Moreover, previous studies found the mandibular premolars and molars to be the most frequent sites for DBIs and our data agree, with 42.5% of DBIs in the mandibular premolar area and 41.4% of DBIs in the mandibular molar area. Since the mandible has more dense trabecular patterns than the maxilla, the morphology of the cancellous bone may play a role in the formation of DBIs.

Location of DBIs Relative to Other Teeth:

In the pre- and post-orthodontic scans, DBIs were most commonly found in the apical region of teeth. The location of DBIs relative to adjacent teeth from most common to least common are as follows: 1) apical, 2) apical and separate, 3) apical and interradicular, 4) interradicular, and 5) interradicular and separate. These results are consistent with findings from other researchers,[1,2,9–13] with the apical region of teeth containing the highest frequency of dense bone islands. It is important to note that dense bone islands are primarily located intimately adjacent to tooth roots, which increases the chances of interactions with teeth during orthodontic tooth movement.

There were nine DBIs that changed location relative to adjacent teeth from the pre- to the post-orthodontic CBCT scan. Four DBI changed from “apical” to “apical and separate.” These four patients were aged 13,14, 26, and 59, during the initial scan. We propose that this change in location could be attributed to vertical growth of the alveolus and jaw bones in growing patients and extrusion of teeth in adults.

One DBI changed from “apical and interradicular” to “apical and separate.” This patient was 9 years old at the time of the initial scan. We propose that this change in location could be attributed to mandibular growth of the patient.

One DBI changed from “apical and separate” to “apical,” one changed from “interradicular and separate” to “apical,” and two changed from “interradicular and separate” to “interradicular.” These findings can be explained by teeth being orthodontically moved and having a different position relative to the adjacent DBI between the initial and final CBCT scan.

Characterizing DBIs in 3D (Aim #1):

The use of CBCT images in this study allowed for a novel categorization of DBIs based on the buccal and lingual positioning. Our data show there was a predilection for DBIs to be associated with the lingual plate of the alveolus, with 70.1% of DBIs in the post-orthodontic scan touching the lingual cortical plate. By contrast, 48.2% of DBIs in the post-orthodontic scan were touching the buccal cortical plate. Only 12.6% of the DBIs were located completely in cancellous bone in the alveolus and did not touch either the buccal or lingual cortical plates.

This information will be helpful to radiologists reporting on DBI locations as well as orthodontists considering tooth movement around DBIs. Taking into consideration that DBIs appear to be associated with root resorption and hindered tooth movement, orthodontists could consider if their treatment plan will be hindered by a DBI that could prevent movement or damage teeth. Although it could be argued that in unique situations DBIs could be used to reinforce orthodontic anchorage, we do not recommend this practice due to the possibility of irreversible damage to teeth.

DBIs in Areas of Potential Tooth Movement (Aim #2):

Our study found that 74.7% of DBI lesions in the post-orthodontic scan were in “areas of potential orthodontic tooth movement,” defined as a DBI extending interradicular and at least into the middle 1/3 of the buccal-lingual dimension of the alveolar process at the DBI site. This finding suggests that when an orthodontist treats a patient with a DBI, it would be reasonable to further evaluate if the DBI is in the area of planned tooth movement, especially given the risk of root resorption and hindered tooth movement adjacent to DBIs.

DBIs and Root Resorption (Aim #3):

In this study, of the 65 DBIs in areas of tooth movement, eight of them (12.3%) were associated with teeth with diagnosed root resorption. This finding is similar to other researchers who found DBI-associated root resorption to be 2-12% [3,16,24]

Teeth with possible resorption were compared to the contralateral teeth to rule out the possibility of root resorption being caused by orthodontic movement alone. In all 8 cases, using contralateral root morphology and root length as a diagnostic guide, the root resorption was diagnosed as being caused by interaction with the DBI.

Additionally, even when DBIs were located in close proximity to adjacent roots, there is no guarantee that the orthodontic treatment would generate enough root movement toward the DBI such that root resorption would be possible or recognizable. Following this logic, it is important to note that the actual ability of DBIs to cause root resorption could be much higher than what was reported in this study.

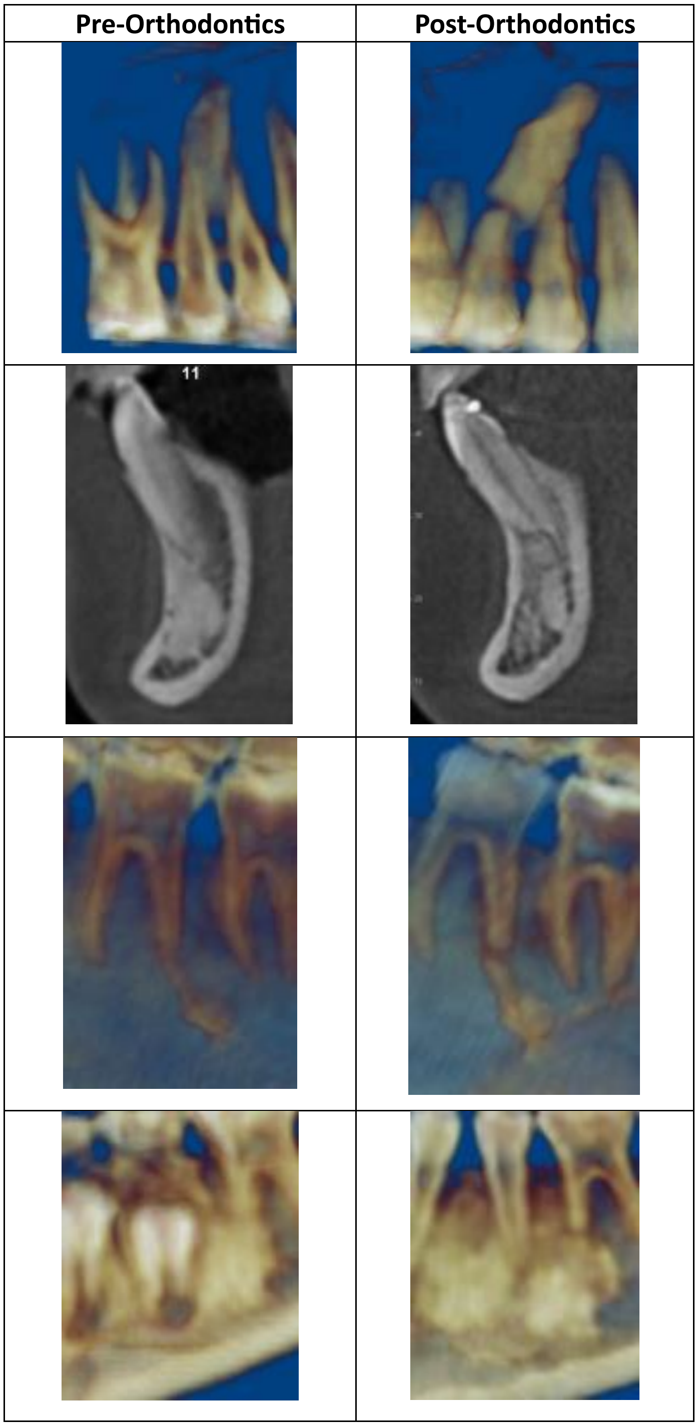


Figure 3: Examples of diagnosed root resorption of teeth associated with DBIs

DBIs and Hindered Root Movement (Aim #4):

Of the 65 DBIs in areas of tooth movement, six DBIs (9.2%) were diagnosed to be associated with hindered root movement during orthodontic treatment. Previous case studies have reported a similar finding[22,25], but to the authors' knowledge, this phenomenon has not been studied before in an orthodontic population.

Although we used objective criteria to assess the possibility of hindered tooth movement (spacing at the end of treatment or greater than 10 degrees of deviation from root parallelism of adjacent teeth), we cannot be certain that the unideal orthodontic result was caused by the DBI and not, for example, poor orthodontic execution.

Additionally, even when DBIs were located in close proximity to adjacent roots, there is no guarantee that the orthodontic treatment would generate enough root movement toward the DBI such that "hindered tooth movement" would be possible or recognizable. By this logic, the actual ability of DBIs to hinder the movement of teeth could be much higher than what was found in this study.

Pre-Orthodontics	Post-Orthodontics
	
	

Figure 4: Examples of hindered root movement of teeth associated with DBIs

Study Limitations:

This study has limitations. Firstly, this study relies on the oral and maxillofacial radiologist to report dense bone islands in their radiology reports. Because DBIs are relatively common and generally believed to not require treatment, it is possible that some patients with DBIs were overlooked. If this were true, it would impact the reported prevalence of DBI lesions. Nonetheless, the prevalence of DBI lesions among various demographic groups has been studied extensively in the past and was not a primary aim of our study. For the purposes of our study, which aims to identifying the potential effect of DBIs on teeth during orthodontic tooth movement, the possibility of overlooked lesions is not a concern.

In addition, as previously mentioned, it would not be possible with this study design to be certain if root resorption and/or hindered tooth movement were caused by association with the DBI rather than being a correlative finding. There was also an element of expert diagnosis required to determine if root resorption and/or hindered tooth movement was observed and whether or not this could be attributed to the interaction with the DBI.

Recommendations for Practitioners:

Our study of DBIs in an orthodontic patient population found that 74.7% of DBIs were in areas of potential tooth movement, and of these DBIs, 12.3% of patients experienced root resorption, and 9.2% experienced hindered tooth movement. Given these findings, we recommend that orthodontists take caution when planning orthodontic tooth movement on patients with DBIs. We also advise that oral radiologists making reports on CBCT images give orthodontists information on the specific 3-dimensional location of DBIs and whether they are in areas of potential tooth movement.

References

1. Geist JR, Katz JO. The frequency and distribution of idiopathic osteosclerosis. *Oral Surg Oral Med Oral Pathol*. 1990;69(3):388-393. doi:10.1016/0030-4220(90)90307-e

2. Petrikowski CG, Peters E. Longitudinal radiographic assessment of dense bone islands of the jaws. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1997;83(5):627-634. doi:10.1016/s1079-2104(97)90131-1

3. Eversole LR, Stone CE, Strub D. Focal sclerosing osteomyelitis/focal periapical osteopetrosis: Radiographic patterns. *Oral Surg Oral Med Oral Pathol*. 1984;58(4):456-460. doi:10.1016/0030-4220(84)90344-X

4. Goaz PW. *Oral Radiology: Principles and Interpretation*. 3rd ed. St. Louis: Mosby; 1994.

5. Eselman Jc. A roentgenographic investigation of enostosis. *Oral Surg Oral Med Oral Pathol*. 1961;14(11):1331-1338. doi:10.1016/0030-4220(61)90264-X

6. Moshfeghi M, Azimi F, Anvari M. Radiologic assessment and frequency of idiopathic osteosclerosis of jawbones: an interpopulation comparison. *Acta Radiol Stockh Swed 1987*. 2014;55(10):1239-1244. doi:10.1177/0284185113515210

7. MacDonald-Jankowski DS. Idiopathic osteosclerosis in the jaws of Britons and of the Hong Kong Chinese: radiology and systematic review. *Dento Maxillo Facial Radiol*. 1999;28(6):357-363. doi:10.1038/sj/dmfr/4600485

8. Solanki J. Prevalence of Osteosclerosis Among Patients Visiting Dental Institute in Rural Area of Western India. *J Clin Diagn Res*. 2015. doi:10.7860/JCDR/2015/11439.6319

9. Kawai T, Fuchihata H. Radiographic investigation of idiopat hit. 1992;74(2):6.

10. Naser AZ, Roshanzamir N. Prevalence of idiopathic osteosclerosis in an Iranian population. *Indian J Dent Res Off Publ Indian Soc Dent Res*. 2016;27(5):544-546. doi:10.4103/0970-9290.195679

11. Fuentes R, Arias A, Astete N, Farfán C, Garay I, Dias F. Prevalence and morphometric analysis of idiopathic osteosclerosis in a Chilean population. *Folia Morphol*. 2018;77(2):272-278. doi:10.5603/FM.a2017.0085

12. Ledesma-Montes C, Jiménez-Farfán MD, Hernández-Guerrero JC. Idiopathic osteosclerosis in the maxillomandibular area. *Radiol Med (Torino)*. 2019;124(1):27-33. doi:10.1007/s11547-018-0944-x

13. Miloglu O, Yalcin E, Buyukkurt MC, Acemoglu H. The frequency and characteristics of idiopathic osteosclerosis and condensing osteitis lesions in a Turkish patient population. *Med Oral Patol Oral Cirugia Bucal*. 2009;14(12):e640-645. doi:10.4317/medoral.14.e640

14. Kawai T, Murakami S, Kishino M, Sakuda M. Gigantic dense bone island of the jaw. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1996;82(1):108-115. doi:10.1016/s1079-2104(96)80387-8

15. Halse A, Molven O. Idiopathic osteosclerosis of the jaws followed through a period of 20-27 years. *Int Endod J*. 2002;35(9):747-751. doi:10.1046/j.1365-2591.2002.00561.x

16. McDonnell D. Dense bone island. A review of 107 patients. *Oral Surg Oral Med Oral Pathol*. 1993;76(1):124-128. doi:10.1016/0030-4220(93)90307-p

17. Wang S, Xu L, Cai C, et al. Longitudinal investigation of idiopathic osteosclerosis lesions of the jaws in a group of Chinese orthodontically-treated patients using digital panoramic radiography. *J Dent Sci*. 2022;17(1):113-121. doi:10.1016/j.jds.2021.05.002

18. Yusof M, Dasor MM, Ariffin F, Reduwan NH, Kamil W, Mah MC. Idiopathic osteosclerosis mimicry of a tooth: case report. *Aust Dent J*. 2020;65(4):308-312. doi:10.1111/adj.12756

19. Bsoul SA, Alborz S, Terezhalmy GT, Moore WS. Idiopathic osteosclerosis (enostosis, dense bone silands, focal periapical osteopetrosis). *Quintessence Int Berl Ger 1985*. 2004;35(7):590-591.

20. Sisman Y, Ertas ET, Ertas H, Sekerci AE. The Frequency and Distribution of Idiopathic Osteosclerosis of the Jaw. *Eur J Dent*. 2011;5(4):409-414. doi:10.1055/s-0039-1698913

21. Al-Habib MA. Prevalence and Pattern of Idiopathic Osteosclerosis and Condensing Osteitis in a Saudi Subpopulation. *Cureus*. 2022;14(2):e22234. doi:10.7759/cureus.22234

22. Mah JK, Yi L, Huang RC, Choo H. Advanced Applications of Cone Beam Computed Tomography in Orthodontics. *Semin Orthod*. 2011;17(1):57-71. doi:10.1053/j.sodo.2010.08.011

23. Marques Silva L, Guimaraes ALS, Dilascio MLC, Castro WH, Gomez RS. A rare complication of idiopathic osteosclerosis. *Med Oral Patol Oral Cirugia Bucal*. 2007;12(3):E233-234.

24. Syed AZ, Yannam SD, Pavani G. Research: Prevalence of Dense Bone Island. *Compend Contin Educ Dent Jamesburg NJ 1995*. 2017;38(9):e13-e16.

25. Huang HY, Chiang CP, Kuo YS, Wu YH. Hindrance of tooth eruption and orthodontic tooth movement by focal idiopathic osteosclerosis in the mandible. *J Dent Sci*. 2019;14(3):332-334. doi:10.1016/j.jds.2019.02.001

26. Alfahad S, Alostad M, Dunkley S, Anand P, Harvey S, Monteiro J. Dense bone islands in pediatric patients: a case series study. *Eur Arch Paediatr Dent*. 2021;22(4):751-757. doi:10.1007/s40368-020-00596-w

27. Baumgaertel S. Socket sclerosis an obstacle for orthodontic space closure? *Angle Orthod*. 2009;79(4):800-803. doi:10.2319/080708-413.1

28. Yonetsu K, Yuasa K, Kanda S. Idiopathic osteosclerosis of the jaws: panoramic radiographic and computed tomographic findings. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1997;83(4):517-521. doi:10.1016/s1079-2104(97)90156-6

29. El Sergani AM, Anderton J, Brandebura S, et al. Prevalence of Torus Palatinus and Association with Dental Arch Shape in a Multi-ethnic Cohort. *Homo Int Z Vgl Forsch Am Menschen*. 2020;71(4):273-280. doi:10.1127/homo/2020/1316

30. Choi Y, Park H, Lee JS, et al. Prevalence and Anatomic Topography of Mandibular Tori: Computed Tomographic Analysis. *J Oral Maxillofac Surg*. 2012;70(6):1286-1291. doi:10.1016/j.joms.2011.12.009