Longitudinal radiographic assessment of dense bone islands of the jaws

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Objectives. This study assessed dense bone island (DBI) inception and growth in jaws.

Study design. A population of 2991 patients (age range 5 to 35 years) was studied with at least two panoramic radiographs taken 1 to 10 years apart for each patient. Lesions were digitized and measured with computer measuring software. The size of the earliest DBI was compared with subsequent DBI measurements after the latter measurement was normalized with reference to the size of the nearest tooth.

Results. Sixty-nine patients with DBIs were identified. A total of 3.1% of the patients with DBI were found in the 5- to 10-year age range, with the first patient in the DBI group found at 9.4 years. A significantly higher proportion ($p = 0.002$) of the unaffected patients (26%) was found in the same 5- to 10-year age range. The proportions of patients in the DBI and unaffected groups in older age ranges were similar. Assessment of DBI size changes showed that 43% of the 53 DBIs detected between 9.4 and 19 years enlarged (mean change, 212%), and 17% diminished (mean change, 49%). In comparison, 29.4% of 17 DBIs detected between 20 and 35 years enlarged (mean change, 153%), and 5.9% diminished (mean change, 60%).

Conclusion. Our results indicate that DBIs are labile lesions, develop during early adolescence, and retain a potential for enlargement, or to a lesser extent shrinkage, into adulthood.

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Dense bone islands (DBIs) are asymptomatic, intrabony, radiopaque lesions that correspond to dense, trabeculated, noninflamed vital bone on histologic evaluation.[1-10] Synonyms for this condition include idiopathic osteosclerosis, bone scar, bone whorl, focal periapical osteopetrosis, enostosis, and eburnated bone. DBIs are not unique to the jaws; they can occur in any bone in the skeleton,[11-13] although extracranial incidence is highest in the pelvis and long bones.[14] Jaw lesions have an overwhelming mandibular predilection that varies between 89.3% and 100%, with presentation primarily in the premolar/molar region.[1, 3, 15, 16] Lesions may occur at root apexes or between roots, or they may separate from teeth. The periodontal ligament space is sometimes obliterated by the mass but may be of normal width or widened. Dense lesions may obscure the root outlines.[17] Root resorption has been reported in association with some lesions.[3]

DBIs occur in young to middle-aged adults without a sex predilection, although a female preponderance has been described in some studies.[1, 15] There is a possible predilection for people of African,[1, 15] Japanese, Chinese, or Indo-Chinese origin.[1, 6, 16]

On radiographic evaluation DBIs appear as localized, well-defined, nonexpansile, radiopaque masses that are round, elliptic, or irregular in shape and are of variable size, ranging from 2 or 3 mm to 1 or 2 cm in diameter.[1, 6, 17, 18] The internal aspect is usually uniformly radiopaque, consisting of a ground glass/stippled appearance[6] or coarse trabeculae that may extend beyond the area of increased density.[17, 18] The radiographic appearance described in skeletal lesions is similar to the appearance noted in the jaws; lesions are usually homogeneously dense with distinctive radiating bony streaks aligned with the axis of the host bone and blend with surrounding trabeculae, creating a feathered or brushlike border.[19]

The cause and biologic behavior of DBIs are not understood. Suggested causes include retained primary root fragments that act as nidi for increased bone formation,[5, 20] bone deposited in response to unusual occlusal forces,[1] or that these lesions represent developmental intraosseous anatomic variations analogous to tori.[2, 4]

The purpose of this study was to assess the inception and growth potential of DBIs by examining patient records in which several radiographs from different time periods were available. Orthodontic diagnostic records were used because they enabled identification of relatively young patients with devel-

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Table I. Definitions of site and internal characteristics of dense bone islands

Site of radiopacity	*Definition*
Interradicular	Limited to the area between the roots and continuous with the lamina duras of at least one adjacent tooth
Interradicular/ separate	Limited to the area between the roots and separate from the lamina dura
Apical and interradicular	At tooth apex with extension between the roots
Apical	Predominantly located around root apex
Separate	Apical and clearly separated from teeth and lamina dura
Internal characteristics	
Radiopaque	Homogeneous radiopacity throughout lesion
Mixed	Nonhomogenous radiopacity with focal relatively radiolucent areas

oping lesions, allowing characterization of lesion growth rate over the period of orthodontic treatment. To our knowledge this is the first study in which lesion development in the jaws was documented.

MATERIAL AND METHODS

The study material was obtained from patient records of a group orthodontic practice. Patient records included demographic (age, race, sex) information, intraoral and extraoral photographs, radiographs, and models. All cases included pretreatment panoramic radiographs and intraoral radiographs in some cases. Follow-up panoramic radiographs taken 1 to 9 years after the first radiograph were available for approximately 99% of the cases.

Cases were included in the study material if a dense bone island was noted in at least one panoramic projection. A DBI was defined as a localized homogenous radiopacity that could be of variable size and shape in the mandible or maxilla and that was unrelated to infection, systemic disease, or other cause. All of the involved teeth were sound, noncarious, or restored with small restorations. Cases where the involved teeth had large restorations in proximity to the pulp horns or dental pulp were excluded. The same criteria as those used by Geist and Katz[1] were used to exclude radiopacities that may have represented other entities:

1. Periapical lesions around teeth with deep caries or large restorations.
2. The characteristic mixed radiopaque-radiolucent areas of periapical cemental dysplasia and other benign fibroosseous lesions of periodontal ligament 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 may represent residual condensing osteitis or excessively ossified surgical sites.

Two observers reviewed the radiographs and agreed on the radiographic diagnosis. Cases in which there was no consensus were excluded from the study. The medical histories of affected patients were reviewed to rule out diseases that are known to affect bone density or bone metabolism. Sixty-nine cases satisfying the previously described criteria were collected. The lesions were classified according to site and internal characteristics as noted in Table I.

All radiographs were backlit with a standard illuminator in a darkened room, and the outline of the DBI and tooth closest to the lesion were traced onto acetate tracing film (3M Unitek Dental Products, Monrovia, Calif.) with a 0.5 mm diameter HB lead pencil. Total tooth area and lesion area were each measured five times and averaged for every case. By repeated evaluation of three cases, precision of the measuring method was determined to be better than 1%. In a pilot study we investigated the effect of tracing variability on area measurements. The outline of the tooth and lesion of three patients were each traced five times, and the tooth and lesion area in these tracings was measured with the video-computer analysis system. The average tracing variability was determined to be 2.5%.

Tracings were digitized with a color video camera (Hitachi VK-350, Hitachi Ltd., Japan) with a macrolens (Macro-Switar f 1. 1 26 mm, Bolex, Switzerland) connected to a Macintosh IIcx computer (Apple Inc., Cupertino, Calif.). Magnification of the digitized images was adjusted to maintain a consistent enlargement of 142 pixels/cm. Images were analyzed with IMAGE V1.37 software (Wayne Rasband, National Institutes of Health). Tracings were oriented so that the region of interest was centered on the computer screen, corresponding to the area of best resolution, and were digitized with frame-averaging (10 frames) to reduce image noise. Brightness and contrast were adjusted to maintain optimum viewing quality before image analysis was performed.

Statistical comparisons for the study cases were

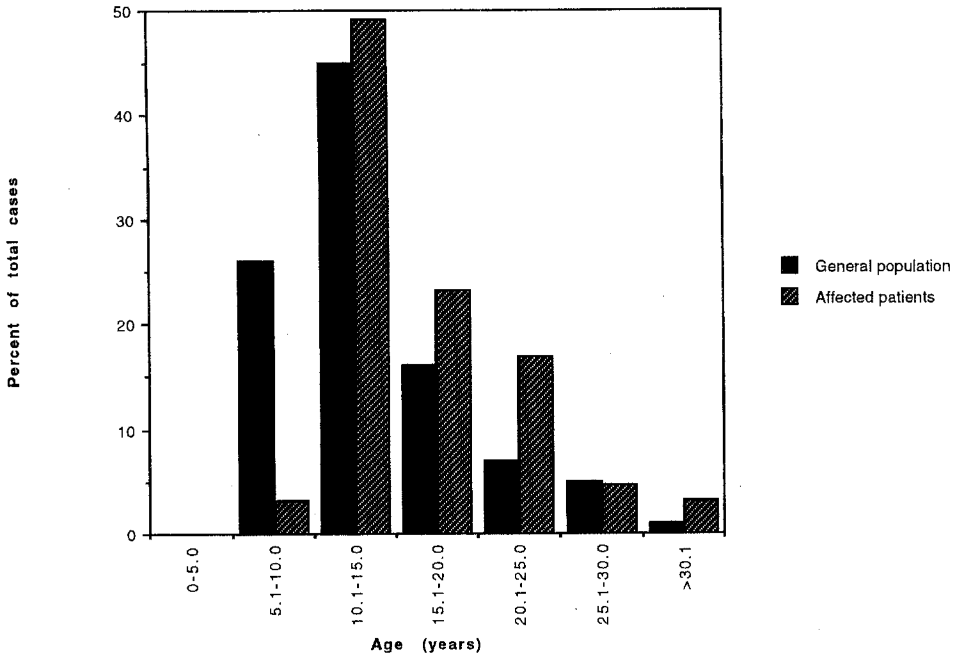

Fig. 1. Ages of affected patients and general patient pool.

performed with two-tailed Gates-corrected chi-squared analysis for proportionate results and *t* tests for descriptive numeric data. Image size variations resulting from possible variations in patient positioning or magnification in different panoramic radiographs were estimated by comparing the sizes of the same tooth measured in radiographs taken at different times. If no variation occurred between the two different radiographs, the ratio of the two measurements taken of the same tooth would be 1 (1:1). However, variations between these two measurements would result in a different ratio and indicate variation resulting from the imaging process, tracing or measuring, or actual movement of the tooth. If the factors producing the variation were acting randomly, a mean value of the ratios from all of our cases would still be very close to one. The actual calculated averaged ratio derived from reference teeth located close to the DBIs in our 69 cases was 1.05 (SD = 0.166). This finding supported our assumption that no systemic bias existed in the imaging, tracing, and measuring process and indicated that the maximum artifactual image size variation between two sequential panographs could reach approximately 33% (equivalent to 2 SD).

To minimize this distortion the following normalization protocol was followed before measurements were compared. The area measurement (a) of the tooth closest to the DBI was compared with the equivalent tooth area measurement (b) from a subsequent radiograph, and the ratio of the two measurements (b/a) was used as a corrective factor to normalize the DBI measurements.

When assessing whether a definite change in DBI size had occurred, we conservatively required a change greater than 30% after comparing the normalized sizes before accepting that a definite DBI size change had occurred.

RESULTS

Incidence

Sixty-nine patients in the DBI group were identified from a patient base of 2991 patients (incidence 2.3%).

Sex predilection

Approximately similar proportions of the patient base (61%) and the DBI group (66%) were female, indicating that DBls do not have a sex predilection ($p = 0.98$).

Age at which DBI lesions develop

The earliest age at which a DBI was detected was 9.4 years. The mean age of the patients in the DBI group (16.7 years, SD = 5.5) was significantly greater ($p = 0.0003$) than the mean age of the patient base (14.0 years, SD = 5.9). Fig. 1 shows that this difference was primarily the result of significantly fewer ($p = 0.002$) patients with DBIs (3.1% of all patients in the DBI group) within the 5- to 10-year age range in

Table II. Anatomic locations of dense bone islands (percent of lesions)

	Anatomic site			
Lesion/lamina dura relationship	*Incisor*	*Premolar*	*Molar*	*Total*
Associated with lamina dura	5	35	38	78
Separate from lamina dura	8	9	5	22
Total	13	44	43	100

comparison with the percentage of all patients (26%) in this age group. The proportions of patients with and without DBIs in the progressively greater age ranges were similar. Collectively, these findings indicate that DBIs first develop in early adolescence.

Site predilection and presentation

There was a predilection for presentation in the mid (43.6%) and posterior (43.6%) mandible and for association with lamina dura (78.2% of all DBIs). Table II shows the predilection for the mid/posterior mandible was caused by the lamina dura-associated lesions; lesions not associated with lamina dura (21.8% of all DBIs) did not exhibit the same site predilection and presented in a marginally greater percentage of cases in the anterior mandible ($p = 0.07$) compared with the lamina dura-associated cases.

Forty-two percent of the lesions were uniformly radiopaque, and 58% had a mixed radiographic appearance at the time the lesions were detected. No correlation was found between anatomic distribution and internal radiographic appearance. Fig. 2 shows typical examples of DBIs changing with time. Multiple lesions were noted in 11.6% of patients with DBIs (seven patients had two lesions, and one patient had three lesions).

DBI size related to age

Fig. 3 shows the mean DBI sizes first measured in different age groups. There is a general trend to larger lesions in older patients. However, only the 9- to 14-year age group had smaller DBIs approaching a statistically significant ($p = 0.09$) size difference.

DBI size changes in lesions detected in adolescents or adults

Follow-up data were available for 70 DBIs. Reexamination of patients after the first presentation over varying time periods showed 40% of all DBI lesions increased in size, 14.3% decreased in size, and 45.7% remained static. Fig. 4 shows that in the 53 cases in which a DBI was initially detected between the ages of 9 and 19 years, 43.4% of the lesions enlarged (mean change, 212%), and 17% showed a size decrease (mean change, 49%). In comparison, Fig. 5 shows that in the 17 cases in which a DBI was initially detected between the ages of 19.1 and 35 years, 29.4% of the lesions enlarged (mean change, 153%), and 5.9% showed a size decrease (mean change, 60%). This result suggests that DBIs in adult cases might be more stable; however, the differences are not statistically significant ($p = 0.12$).

It was not possible to relate DBI size or size changes to sex, lesion location, or lesion relationship with lamina dura. Further attempts to relate size or size changes of the lamina dura-associated lesions to the position of the DBI around the tooth root as noted in Table I were also negative (results not shown).

DISCUSSION

Previous studies describing the presentation and behavior of DBIs in the jaws have used cross-sectional radiologic surveys of primarily adult populations. We selected a population composed primarily of preadolescent and adolescent patients who had received a pretreatment and at least one follow-up panoramic radiograph during the course of orthodontic treatment for this retrospective study. This group of patients provided an unusual opportunity to observe the longitudinal behavior of DBIs from periods of time predating their inception to 1 to 10 years after their inception.

The results of this study generally supported previous findings indicating DBIs have an overwhelming mandibular predilection, preferred presentation in the premolar/molar region, no sex predilection, and in a small minority of patients can present as multiple lesions. Studies that have distinguished between lamina dura-associated lesions and distant lesions in basal bone have indicated that this distribution is approximately similar in Asian populations,[6, 16] although only approximately 20% of cases occur in basal bone in other populations.[1] Our results showing 22% of DBIs in basal bone closely approximate those of the latter study. In addition, we found that basal bone lesions did not have the previously noted premolar/molar region predilection, although the significance of this finding is unclear.

DBI incidence in this study (2.3%) is somewhat lower than the range of 3.5% to 8% noted in other

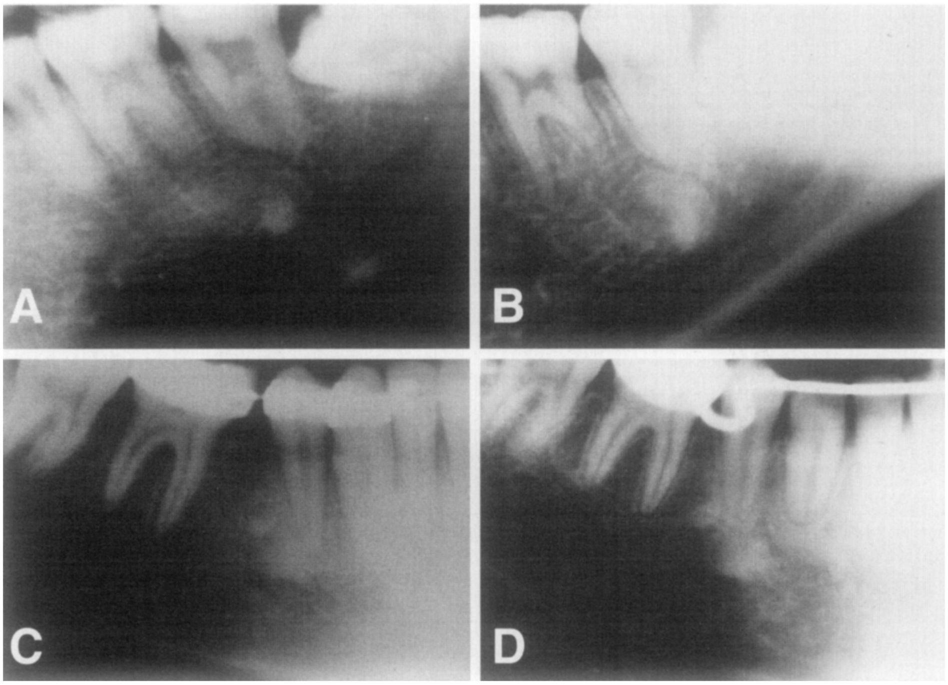

Fig. 2. **A,** Asian man 22 years, 6 months old. DBI apical to left mandibular second molar. **B,** Same patient as in Fig. 2, *A,* 24 years, 4 months old. DBI has enlarged, and superior aspect conforms to tooth root outline. **C,** White girl 14 years, 1 month old. DBI associated with lamina dura at distal aspect of tooth 44. **D,** Same patient as in Fig. 2, *C,* 17 years, 6 months old. Lesion is smaller.

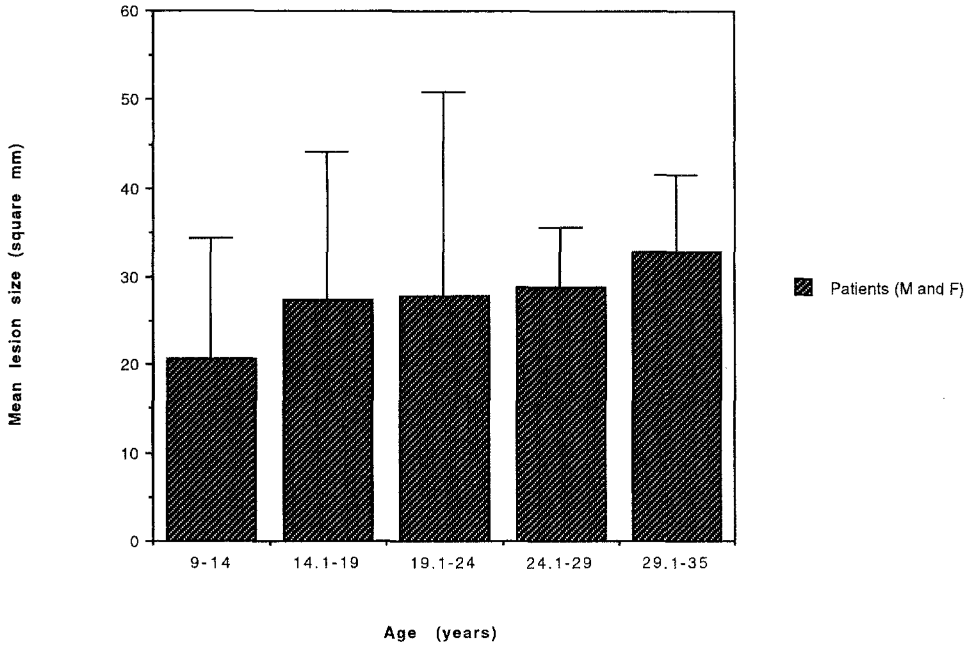

Fig. 3. Mean lesion size at first presentation in different age groups.

studies.[1, 5, 6, 21] This is probably because approximately 26% of our patient base was between the ages of 5 and 10 years, but the youngest patient in the DBI group was 9.4 years old. Thus the large numbers of preadolescent patients without DBIs would result in a lower incidence than that derived from studies of older patients. The further clear inference is that DBIs do not begin to develop until early adolescence.

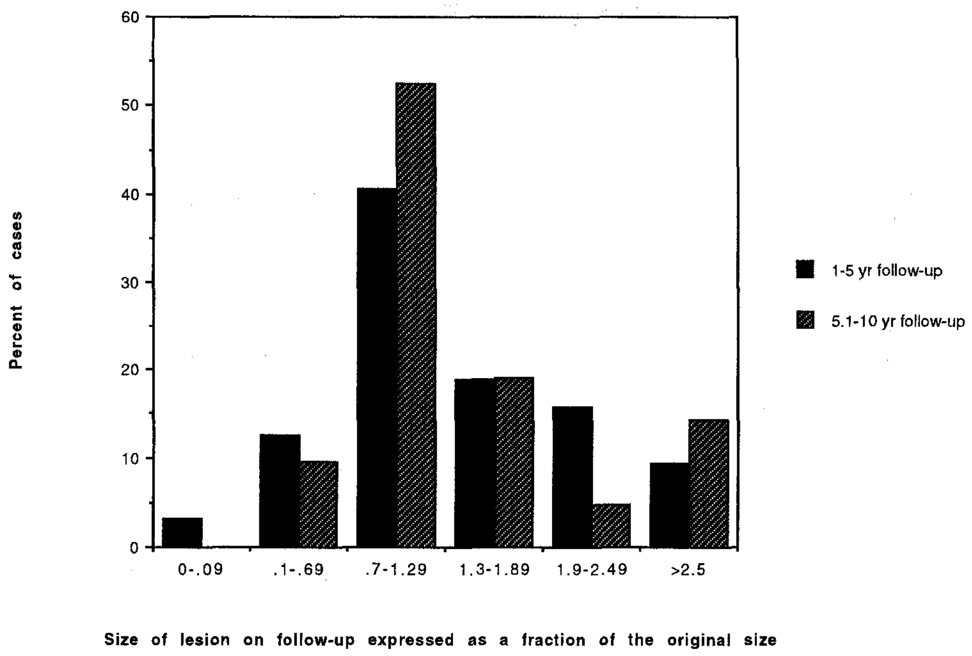

Fig. 4. Lesion size changes in patients first diagnosed between ages of 9 and 19 years.

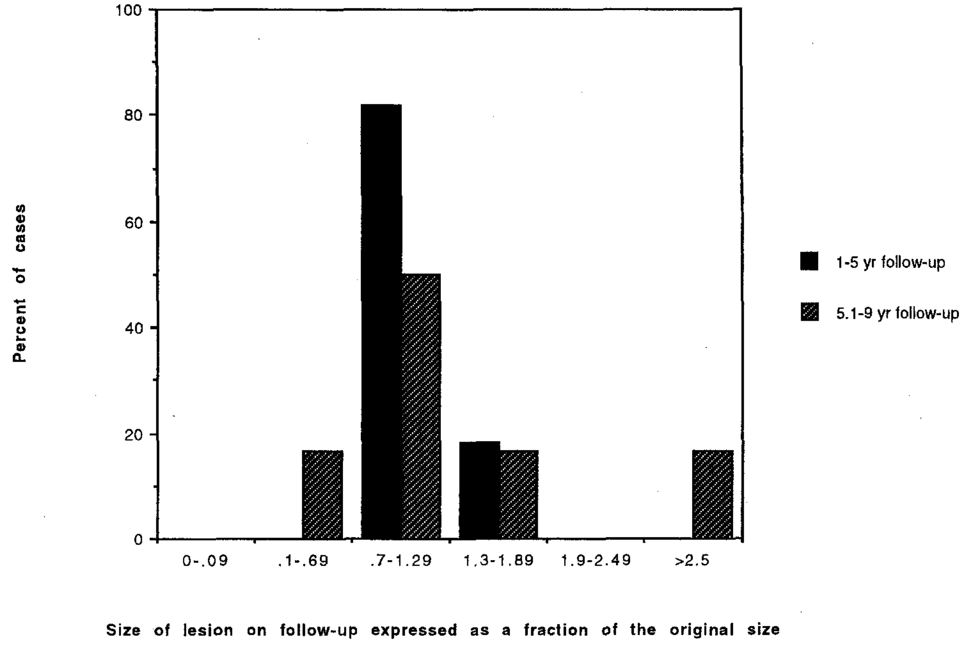

Fig. 5. Lesion size changes in patients first diagnosed between ages of 19.1 and 35 years.

Direct measurement of the panoramic image to determine lesion size is inaccurate because of differential magnification and distortion in panoramic images.[22-31] Comparison of DBIs in the jaws at different times was facilitated by reference to the nearest tooth, which acted as a reference point to normalize the radiographic measurements. Even after this normalization, our results indicate that DBIs are labile lesions; at least 40% of DBIs enlarged and 14.3% diminished after follow-up periods of 1 to 10 years. This lability was most pronounced for lesions detected during adolescence, although a similar trend was noted for lesions detected in young adulthood. Because some patients had DBIs in areas that were undergoing orthodontic tooth movement, we initially hypothesized that lesion size could be influenced by orthodontic forces. However, we were unable to detect any relationship, and the same profile of lability was found in DBIs contiguous to and distant from lamina dura. Other attempts to relate the lability to factors such as position within the mandible, radiographic characteristics, or sex were also not successful. Three of our cases demonstrated virtually complete regression of the lesion on follow-up, a phenomenon that has not been previously described in the jaws. One of the jaw lesions that regressed was located at the ridge crest between the left mandibular first molar and the second bicuspid, another was located interproximally between the left mandibular bicuspid and the first molar in close association with the lamina dura, and the third was interproximal to but not associated with the lamina duras of the second mandibular bicuspid and the first molar. Analogous studies of DBIs in the extragnathic skeleton have indicated a similar lability.[12, 32-34] A single study in which extragnathic DBIs were measured at different time intervals, although performed without any attempt to normalize radiographic measurements, indicated that approximately 32% of DBIs enlarged and 3% diminished over periods from 3 to 23 years.[33] Other long bone studies have also anecdotally reported enlarging DBIs.[12, 13] Of related interest, none of these studies included jaw lesions, and the general radiology literature suggests such lesions do not occur in the skull.[35]

Long bone DBIs are thought to represent a developmental error of normal bone turnover occurring in endochondral bone.[14] The reason endochondral bone appears susceptible to DBI formation is not clear, but it is interesting that the vast majority of jaw DBIs also occur in the mandible, which is of endochondral origin. However, DBIs appear to be responsive to systemic hormonal influences; complete disappearance of a DBI was noted in a patient with hyperparathyroidism. This lesion recurred when the causative adenoma was removed, suggesting the importance of local factors and emphasizing the lability of DBIs.[36] Abnormal bone remodeling theories have also been suggested for jaw lesions. In one study cortical bone forming a nutrient canal was implicated as a possible focus for DBI formation.[1] Similarly, we noted the development of a DBI from the cortical bone surrounding a dental crypt in one of our cases. Other theories of gnathic DBI development that have implicated uniquely dental stimuli such as retained roots or occlusal forces are not incompatible with the idiopathic remodeling defect theory. The abnormal remodeling that results in the sclerotic vital bone composing the DBI could be controlled by a variety of etiologically distinct mechanisms.

The differential diagnosis of DBIs in long bones includes calcifying enchondroma, medullary bone infarct, healing nonossifying fibroma, osteoid osteoma, osteoblastoma, sclerotic metastases, and osteosarcoma.[14] In the long bones the most significant distinction is from an osteosarcoma or osteoblastoma. In the event of a radiologic or clinical ambiguity, scintigraphy is considered a useful adjunct. However, several reports of scintigraphically active DBIs indicate this is not a definitive test.[14, 19, 37, 38] The fact that DBIs often take up radioactive nuclides are consistent with our findings and those of others that a significant fraction of these lesions are labile and therefore metabolically active. As a final point a case of a putative DBI has been described that subsequently proved to be an osteosarcoma.[39] This occurrence has resulted in the suggestion that biopsies of growing DBIs should be performed, although this has not been reconciled with reports that a significant number of these lesions enlarge with time. For practical purposes in cases of jaw lesions, calcifying enchondroma, medullary bone infarct, healing nonossifying fibroma, osteosarcoma, and osteoid osteoma can usually be eliminated from the differential diagnosis. However, jaw DBIs must be distinguished from condensing (sclerosing) osteitis of dental origin or other root-associated radiopacities such as periapical cemental dysplasia, cementoblastomas, or less problematically, gigantiform cementomas.

In summary, this study indicates that jaw DBIs first develop during early adolescence, usually in the mandible. They are labile lesions that often enlarge and less commonly, shrink, and this lability appears to be expressed more commonly in adolescence. However, attempts to relate this to other factors such as radiologic characteristics, lamina dura association, anterior/posterior position in the mandible, or sex were negative. Lesions that present in the basal bone do not appear to have the molar/premolar predilection of the lamina dura-associated lesions.

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