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Relevance of Lamina Dura in Health and Disease: A Diagnostic Landmark

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Abstract

The appearance of the lamina dura is a valuable diagnostic feature; any deviation is highly suggestive if not indicative of an abnormal condition. Dentists often are the first to detect a serious general condition from recognition of local oral changes. The dentists are therefore advised to consider other signs and symptoms, as well as the integrity of the lamina dura, when establishing diagnosis and treatment of local and systemic disorder.

Keywords: Lamina Dura, Alveolar Bone, Hard Layer

Introduction

The endeavour to live free of diseases is everyone's dream and struggle in reality. The purpose of medical practice is to fulfill that dream, by relief of suffering. In order to achieve this purpose it is important to have thorough knowledge and proper approach to the treatment and to design appropriate scheme of management for every patient[1].The diagnostic sequence consists of demographic information of the patient with adequate history, appropriate investigations such as chair side, radiographic, laboratory investigations and so on. Currently radiographs are the accurate and least subjective diagnostic aid available and are essential for the detection of osseous abnormalities in maxilla and mandible. Pathological changes in bony architecture and disease progression can be followed with radiographs. Density and gray scale changes in radiographs are important visual features the clinician uses to evaluate changes in bone pattern. With advances in technology, researchers are constantly seeking ways to enhance radiographic diagnostic accuracy[2]. Indeed they evolve and change as new techniques and concepts arise[1] Manson defines lamina dura as the internal septum that normally presents thin radioopaque border adjacent to periodontal ligament and the crest. This structure can vary greatly in normal state although some alterations actually represent pathological changes[3].

The normal structure of lamina dura can vary in depth and width caused by number of factors. Variations in thickness are found around different teeth in the mouth and even around single teeth. The manner in which radiograph is taken also result in an impression of irregularity. There are also investigators however who state that discontinuity of lamina dura is usually evidence of generalized calcification[3].Thus, although the state of the lamina dura could be valuable for diagnosis, identification of its disruption is frequently difficult because small variations and disruptions in its continuity may result from superimpositions of cancellous bone and small nutrient canals passing from the marrow spaces to the periodontal ligament[4].Although current available literature suggests that there is some degree of changes in Lamina Dura in many of systemic diseases as well oral diseases but there

is pressing need to characterize the diseases that cause the disturbances in lamina dura as well its state in the healthy condition.

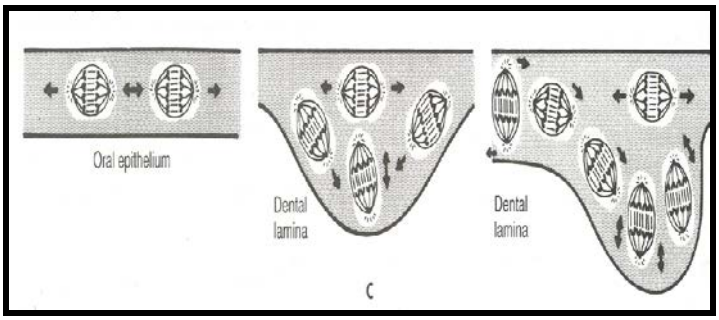
History of Lamina Dura

Maury Massler [1945][5] Investigated the significance and structural characteristics of lamina dura, changes in its appearance during various types of tooth movements and in systemic disease. Frank E. Beube [1949][6] proposed the various factors in the repair of alveolar bone and cementum. Grace Petrikowsk [1995][7] attempted for radiographic differentiation of osteogenic sarcoma, osteomyelitis, and fibrous dysplasia of the jaws and concluded that diagnosis cannot rely on radiographic characteristics alone, although some radiographic findings were more useful than others. Domenico Ricucci et al [2006][8] said that diagnosis of periapical lesions cannot be made on the basis of the presence or absence of a radiopaque lamina, but requires histological examination of serial sections. **Minoru Yamaoka et al [2010]**[4] highlighted the association of bone formation with disruption of lamina dura below the crown of the mandibular horizontal incompletely impacted third molar.

Development of Lamina Dura

Around 27th day of gestation bucco-pharyngeal membrane ruptures leading to establishment of connection between primitive oral cavity and foregut. After 2 weeks a narrow band of thickened epithelium on developing mandible and maxilla is observed forming 4 zones one in each quadrant which thickens and invaginates into mesenchyme to form Primary Epithelial Band which is 1st histologic sign of tooth development.[9]This band is divided into vestibular lamina which is buccally or facially located and dental lamina is lingually located. Vestibular lamina is a lip furrow band or labial or buccal lamina or buccogingival lamina which contributes to development of vestibule delineating the lips and cheeks from tooth bearing regions.[9] The first evidence of tooth formation in humans is observed as a thickening of the oral epithelium in the mandibular, maxillary, and medial nasal processes in the 1-month-old fetus. It has been suggested that the zone of epithelial thickening (the dental plate or placode) contains the genetic determinants for the initiating signals that regulate the number and position of the future tooth buds.[10] At a slightly later stage of development, the epithelium invaginates into the underlying mesenchyme to form the dental lamina. It is lingually located primary epithelial band, progressing bilaterally forming 2 horse shoe shaped bands defining prospective upper and lower dental arches which are shallow initially but gets deeply established within a week which is a germinal band of epithelium circumscribing future maxillary and mandibular arches.[9]This lamina multiply faster at 10 places in maxillary and 10 in mandibular than, its adjacent cells leading to formation of 10 little fenols of epithelial cells on dental lamina of each jaw called Dental Organ or Enamel Organ which marks beginning of tooth germ of primary teeth.[9] After primary tooth develops from buds lingual extension of lamina continue to grow to develop permanent teeth which succeed 20 primary teeth known as successional lamina. This development is seen from 5th month inutero to 10th month of age. Later general lamina explained above continues to grow posteriorly into elongating jaw and from it develops 12 posterior permanent teeth which function till 5th year of life.[11]

Fig. 1: Origin of dental lamina



Anatomy of Lamina Dura

The part of the maxilla and mandible which supports and protects the teeth is known as the alveolar bone. The alveolar bone consists of outer cortical plates, a central spongiosa and a bone lining the socket. According to function, to which the alveolar process adapts itself, it is divided into Alveolar Bone Proper and Supporting Alveolar Bone.[9]

Alveolar Bone Proper surrounds the root of the tooth and gives attachment to the principal fibers of the periodontal ligament which is a thin lamella of bone. Principal fiber bundles embedded in the alveolar bone proper are the Sharpey's fibers. This bone which lines the socket in which Sharpey's fibers are embedded is known as bundle bone which is also known as lamina dura because its radiopacity. The radiopacity is due to the thick bone without any trabeculations. But, it may also be due to the mineral content or orientation of the bone crystals.[11] Supporting alveolar bone is the bone that surrounds alveolar bone proper and gives support to the socket. It consists of Cortical Plates and Spongy bone. Cortical Plates consist of compact bone and form the outer and inner plates of the alveolar process whereas spongy bone is the bone which fills the space between the outer and inner plates and the alveolar bone proper.[9]

Normal Radiographic Features of Lamina Dura

A radiograph of a sound tooth in normal dental arch demonstrates that the tooth sockets are bounded by thin radio-opaque layer of dense bone. The word “lamina” is derived from ***latin word lamin,*** which means layer/slice. However its name stands now for radiographic appearance. This layer is continuous with the shadow of the cortical bone at alveolar crest.[12]

Its radiographic appearance is caused by the fact that the x-ray beam passes tangentially through many times the thickness of the thin bony wall, which results in its observed attenuation (egg shell effect). Developmentally the lamina dura is an extension of the lining of the bony crypt that surrounds each tooth during development.[12]

Gotellib and Orban [1938][13] stated about *changes of lamina dura with age*, the thickness and radiopacity of lamina dura continues to diminish after the tooth is in full clinical occlusion as the individual becomes older, but normally doesn’t disappear altogether.

Kronfeld [1939][13] stated that, lamina dura is thick and prominent and periodontal space is wider at the mesial surface of root in its gingival two thirds. This corresponds to area of apposition of new bone in the histologic section.

Shanks and Kerley [1951][14] have stated, “The reason lamina dura is seen in radiogram and can be distinguished from surrounding alveolus is that the bone of which it consists is denser and more radioopaque than the surrounding structures” they further stated that, “we feel this is not the reason the alveolar bone proper shows the thin radioopaque line; we believe rather it is due shape of socket.

Goodman et al [1957][15] stated that, the lamina dura registration resulted from the presence of dense bone extending the full bucco lingual width of tooth. It is quantity not the character of bone that determines the typical radiographic findings.

White and Pharoah [2000][16] said that lamina dura is a radiographic image that may vary in sharpness with x ray beam angulations possibly due to disruptions along lamina dura.

Table 1- Classification Of Lamina Dura In Changes

I. Loss Of Lamina Dura Based On Etiology

1. Local causes:	2. Systemic causes	3. Others
i. Periapical inflammatory lesions	i. Fibrous dysplasia	i. Metastatic malignancies of jaws
ii. Periodontal inflammatory lesions	ii. Pagets disease	
iii. Odontogenic cysts of jaws	iii. Rickets	
iv. Orthodontic treatment	iv. Osteomalacia	
v. Benign tumours & malignant tumours	v. Hypophasphatasia	
	vi. Renal osteodystrophy	
	vii. Hyperparathyroidism	

II Loss Of Lamina Dura—Localized

1. Common normal variations:	2. Pathologic:
• Apex of maxillary canine rotated tooth	• Inflammatory periapical disease
• Maxillary premolars—before maturation	• Periapical granuloma
• Projection over maxillary sinus projection over mandibular canal projection over mental foramen	• Radicular cyst
	• Simple bone cyst
	• Periapical cemental dysplasia
	• Osteomyelitis
	• Benign and Malignant tumors
	• Fibrous histiocytoma
	• Histiocytosis X

III. Loss Of Lamina Dura—Generalized

• Idiopathic	• Rickets (including vitamin D-resistant rickets)
• Paget disease of bone	• Cushing syndrome
• Fibrous dysplasia of bone	• Postmenopausal osteoporosis
• Leukemia	• Renal osteodystrophy
• Metastatic malignancy (especially breast)	• Acromegaly
• Hyperparathyroidism	• Hypervitaminoses D
• Multiple myeloma	• Systemic sclerosis (scleroderma)
• Osteomalacia	• Hyporphosphatasia

IV. Thickened Lamina Dura

- Osteopetrosis
- Occlusal trauma

Lamina Dura Changes In Periapical Inflammatory Lesions

Lamina Dura Changes in Apical Periodontitis- Periodontitis caused by infection of the pulp canal system has been termed apical periodontitis, apical granuloma/cyst, periapical osteitis, periradicular periodontitis, among other terms.[17] Resorptive and bone remodeling activities in response to the inflammation are the main causes of changes that become visible on the radiograph.[18] Langlais, Langland, Nortje[19] states that, on radiographs of acute apical periodontitis, may exhibit small periapical radiolucency or slight thickening of periodontal ligament at the apex of tooth or it may appear normal.

Lamina Dura Changes in Periapical Abscess- Infections that involve periapical region most often are a result of inflammation and necrosis of dental pulp.[20] The radiographic features vary depending on the time course of the lesion because very early lesion do not show any radiographic changes. More chronic lesions may show lytic (radiolucent) or sclerotic (radioopaque) changes or both.[16] **Stuart C. White et al[21]** states that, in acute apical abscess the radiographically the periapical tissue may appear normal because fulminating infections may not have enough time to erode even cortical bone. Stafne[20] states that, the earliest radiographic evidence of acute periapical abscess is widening of periodontal membrane space in apical region and in chronic phase chronic phase widening of periodontal ligament space, diffuse radiolucency at the apex of tooth is present.

Periapical Granuloma and Periapical Cyst- A growing mass of granulation tissue surrounding the apex of a nonvital tooth and arising in response to necrosis of the tooth pulp which is also called apical granuloma, dental granuloma. Stafne[20] states that, radiographically a granuloma is seen as a round or oval radiolucency that extends away from the apical portion of the root of the tooth. The borders are more often fairly well

circumscribed, but in general they are not as definite and well demarcated, nor do they extend abruptly away from surface of root,as is true of small fully developed radicular cyst. Ernest R et al [1968][22] frequency of both cysts and granulomas was one and one-half times greater in the maxilla than in the mandible. Radicular cysts were found to be almost as common as granulomas in both posterior and anterior areas of the mouth

Lamina Dura Changes in Osteomyelitis- Osteomyelitis is defined as an inflammation of the bone marrow with a tendency to progression. It involves adjacent cortical plates and often periosteal tissues.[23] In acute osteomyelitis it is very common to see swelling and erythema of the overlying tissues, which are indicative of the cellulitic phase of the inflammatory process of the underlying bone.[24] Langlais, Langland, Nortje[19] states that, there are no significant lamina dura changes in actue stage of osteomyelitis. **Stuart C. White et al[16]** states that, The roots of teeth may undergo external resorption, and the lamina dura may become less apparent as it blends with the surrounding granular sclerotic bone. **Stafne[20]** states that, lamina dura becomes less apperant in chronic osteomyelitis.

Lamina Dura Changes in Periodontal Lesions- Periodontitis results from the extension of gingival inflammation to involve the remainder of the periodontium. **Stuart C. White et al[16]** states that,if the inflammatory disease is permitted to progress, resorption of the crestal portion of the alveolar process may occur. This is evidenced in the radiograph by loss of a distinct crestal lamina dura and a cup-shaped notch or scalloping of the crest. The resorption may proceed apically on a horizontal level .Beyond this, the lamina dura appears to be normal without widening of the periodontal ligament space.

Lamina Dura Changes in Periodontal Abscess- A periodontal abscess is a localized accumulation of pus within the gingival wall of a periodontal pocket resulting in the destruction of the collagen fiber attachment and the loss of nearby alveolar bone.[25] Periodontal abscess may be acute or chronic; an acute periodontal abscess resulting from trauma or introduction of infection into a healthy periodontium shows no radiographic signs with the possible exception of slight widening of the periodontal space.[19]

Lamina Dura Changes in Occlusal Trauma- Occlusal trauma refers to a response or effect and is defined as an injury to the attachment or tooth as a result of excessive occlusal forces. Primary occlusal trauma is injury resulting from excessive occlusal forces applied to a tooth or teeth with normal support, while secondary occlusal trauma is injury resulting from normal occlusal forces applied to a tooth or teeth with inadequate periodontal support.[26] Increased tooth mobility is not always indicative of trauma from occlusion.[27] **S. J. Davies[2001][28]** described, common radiographic signs of occlusal trauma are **discontinuity and thickening of lamina dura**, widening of periodontal ligament space (‘funnelling or saucerisation’) and radiolucency and condensation of alveolar bone/or root resorption.

Lamina Dura Changes in Orthodontic Teeth Movement- Before orthodontic treatment is initiated, most roentgenograms show lamina dura of usual thickness and radiopacity. **Rehak [1935][29]** has made a careful analysis of the "Roentgeno-graphic Interpretation of Bone Changes in Orthodontic Tooth Movement." During treatment and after tooth movement has been instituted, the roentgenogram reveals a lamina dura that is distinctly wider and markedly radiopaque on the bony surface from which movement is occurring (area of tension). The surface upon which new bone formation occurs as a result

of the orthodontic procedure shows a wider and more radiopaque lamina dura.

Lamina Dura Changes in Cyst- A cyst is a pathologic cavity having fluid, semifluid, or gaseous contents that are not created by the accumulation of pus; frequently, but not always, it is lined by epithelium **[Kramer 1974][30]**. **S C White & M J Pharoah[16]** states that, in case of **odontogenic cysts**, periodontal ligament is widened; the lamina dura of the involved teeth is destroyed. **Robert Langlais, Langland, Nortje[19]** states that **non-odontogenic cysts**, they might displace teeth but periodontal ligament and lamina dura remain intact**.** In odontogenic cysts, periodontal ligament is widened, the lamina dura of the involved teeth is destroyed.

Lamina Dura Changes in Benign Tumours of Jaws- Benign tumors are slowly growing and spread by direct extension without metastases.[12] **Stafne[20]** states that, benign lesions displace teeth possibly compressing lamina dura, and benign lesions of the cementum displace lamina dura out away from the tooth. Langlais, Langland, Nortje[19] state that benign lesions cause loss of lamina dura.

Lamina Dura Changes associated with Fibroosseous Lesions- Worth [1963][31] states that , fibrous dysplasia exhibits finger print bone pattern that may be useful and distinguished feature. Fibrous dysplasia shows altered lamina dura pattern. Destruction of cortical boundaries is well documented feature of malignancy. Superior displacement of mandibular canal is strongly suggests diagnosis of fibrous dysplasia. **Allan Farman et al[32]** states that loss of lamina dura and obliteration of periodontal space is evident in Paget's disease. Stafne[20] states that, there is loss of lamina dura in Periapical cemental dysplasia. The tooth structure usually is not affected, although in rare cases some root resorption may occur.

Lamina Dura Changes in Primary Intraosseous Carcinoma of Jaws- The condition may be asymptomatic, painful and may mimic localized periodontal disease of practical dental importance is that mobility of the teeth is one of the first clinical signs.[33] **Stuart C. White et al[12]** state that, lesions are capable of causing destruction of antral and nasal floors , loss of cortical outline and effacement of lamina dura. Root resorption is unusual. Teeth that lose both lamina dura and supporting bone tend to be floating in space.

Lamina Dura Changes in Leukemia- Leukemia is characterized by the progressive overproduction of leukocytes that usually appear in the circulating blood in an immature form.[19] **Worth [1963][31]** suggests that**,** the jaws usually escape radiologic change, but when they are involved, there is a pattern consisting of a uniform osteoporosis leading to increased radiolucency and effacement of the lamina dura. **Peterson and co-workers [1983][34]** reported an unusual instance of leukemic infiltrate at the apex of a mandibular second molar in an adult with relapsed ALL. The oral symptoms resemble those of pulpal disease requiring root canal therapy.

Conclusion

Lamina dura can vary greatly in normal state although some alterations actually represent pathological changes. The correlation of systemic health with presence of lamina dura may serve to indicate the dentist the physiological status of individual.These findings lead to inference that lamina dura is diagnostic of pathology, but has to be correlated with other clinical findings for appropriate diagnosis and treatment plan.

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