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Tooth ankylosis in man and the oxytalan fibre meshwork

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Abstract

There is no published information on the presence of the oxytalan fibre meshwork in the periodontal ligament of human ankylosed teeth. Contrary to the limited term experimental animal study of Hurst (1972), the present investigation demonstrates that extensive oxytalan structures can persist over many years in the presence of ankylosed teeth. Human biopsy material of four ankylosed first and second permanent molars exhibited a well-defined oxytalan meshwork that linked the teeth and periodontal vessels to each other proving that oxytalan-vascular associations are maintained in the absence of tooth oscillation. Thus, oxytalan fibres are not only found in connective tissues subject to stress (Fullmer et al. 1974), but also in the relatively stress-protected periodontium of submerged teeth. These findings raise new questions regarding the possible functional role of the oxytalan fibre meshwork.

Key Words: Oxytalan meshwork, ankylosis, human teeth.

INTRODUCTION

Data on the anatomical arrangement of the oxytalan fibre meshwork in the periodontal ligament of the permanent dentition in man have been published by Sims (1975a, 1975b, 1976) and others including Fullmer (1958, 1967), Fullmer Sheetz and Narkates (1974), and Simpson (1967). Hurst (1972) reported that following the autologous reimplantation of monkey incisors oxytalan fibres decreased in size and number as ankylosis proceeded in the periodontal ligament over a six week period. He concluded that ankylosis and fibre degeneration may be related to the quality of the regenerated fibres and the lack of functional stimulation during fibre regeneration.

Information is lacking on the prolonged effects of ankylosis upon the human oxytalan fibre system. The present investigation describes oxytalan meshwork and tissue changes associated with ankylosis affecting the permanent molars of an adolescent male over an eight year period. Findings in this study differ markedly from those reported by Hurst in his short-term animal experiments.

MATERIALS AND METHOD

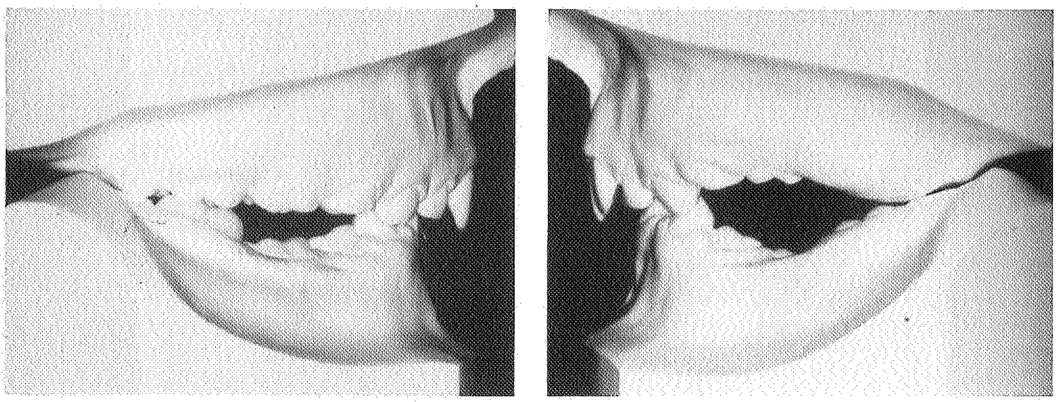
When the patient was first seen at the age of six years he presented with the following erupted teeth $\frac{\text{6edcb 1 1 bcde}}{\text{6edcb21 12 bcde6}}$. Ankylosis was then evident in the deciduous molars of the left maxillary and mandibular quadrants and the right mandibular region. The first permanent molars on the left side were also involved (Figs 1, 2). Intra-oral X-rays did not provide definitive evidence of tooth-bone union. Treatment was not proposed at this initial consultation. Three years later, all deciduous molars were removed under general anaesthesia. At 14 years of age the patient again reported for examination and showed marked ankylosis of the first permanent molars and other adjacent teeth (Figs 3, 4, 5). These teeth were all clinically immobile and radiographically a typical lamina dura was absent (Fig. 6). Since the posterior teeth lacked functional occlusion the four first and second permanent molars were surgically removed under local anaesthesia. A specimen of buccal bone and gingival tissue was left attached to the maxillary left and right first molars and the mandibular right first molar.

The teeth and adhering periodontium were fixed in 10 per cent buffered neutral formalin, decalcified in 5 per cent nitric acid and processed for histological study. Serial sections were cut at 8 micro-metres in the mesiodistal or buccolingual direction. For light microscopy examination the tissues were oxidized with oxone (Rannie 1963) and stained with a modified version of the aldehyde fuchsin technique advocated by Fullmer et al. (1974). Haematoxylin and eosin or Erlich's haematoxylin (Luna 1958) were also used on selected sections.

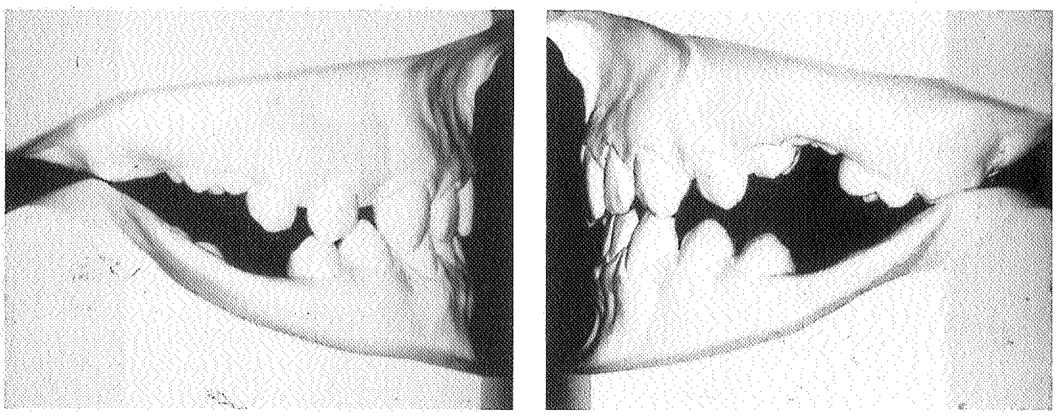
FINDINGS

Microscopically the roots of the teeth appeared enlarged with blunt rounded apices. The interradicular regions were reduced in size as the result of hypercementosis and demonstrated more irregular surfaces than the outer aspects of the roots. Buccal bone specimens were firmly united to the teeth whereas the overlying gingival tissues were of normal appearance and consistency.

Histological staining revealed a number of characteristic features common to all molars. Pulp chambers were reduced in size by extensive deposits of secondary dentine, particularly over the floor and extending along the root canals.



Figures 1, 2 Right and left sides of plaster casts of the dentition. Age, 6 years.



Figures 3, 4 Plaster casts of the dentition made prior to extraction of the permanent ankylosed molars at the age of 14 years.

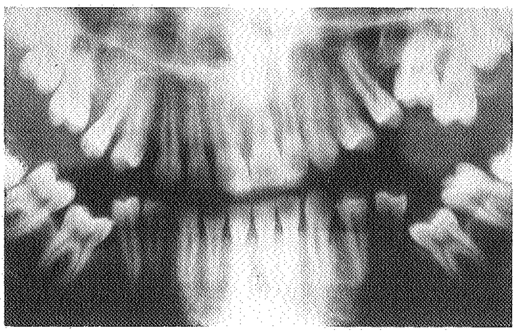


Figure 5 Orthopantomograph X-ray at the age of 14 years.

Figure 6 Periapical X-ray of the ankylosed mandibular right first molar before surgical removal.

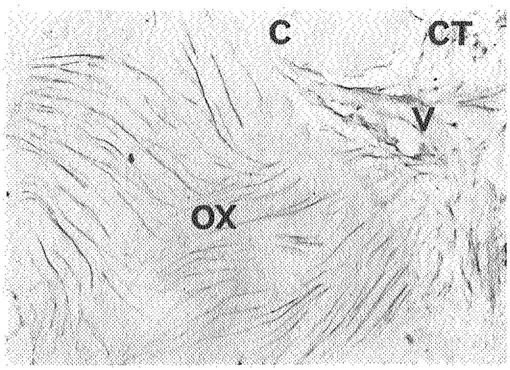


Figure 7 Random oxytalan fibre arrangement tangential to the buccal root of the left maxillary molar. C cellular cementum; CT connective tissue enveloping root surface; OX oxytalan fibres; V vessel. Maxillary left molar, palatal root. Oxone, aldehyde fuchsin, light green. × 200

Numerous sites of ankylosis involving dentine resorption and repair with characteristic reversal and incremental lines were observed between the cervical and apical limits of the roots and found to be particularly prominent in the interradicular areas. The original layer of acellular cementum enveloping the dentine was covered by multiple layers of calcified tissue which contained numerous cells and resembled cellular cementum or bone. Incremental lines clearly demarcated separate stages of cementum deposition. In the apical regions the hypercementosiz formed the thickest deposits. Some localities also demonstrated isolated and irregular layers of tissue similar to acellular cementum interspersed between the strata of hypercementosis. Patterns of concurrent resorption and apposition were present throughout the hypercementosis. The outer surface of each root was covered by a thin layer of adhering connective tissue containing large numbers of oxytalan fibres usually displaying a random orientation (Fig. 7). However, some

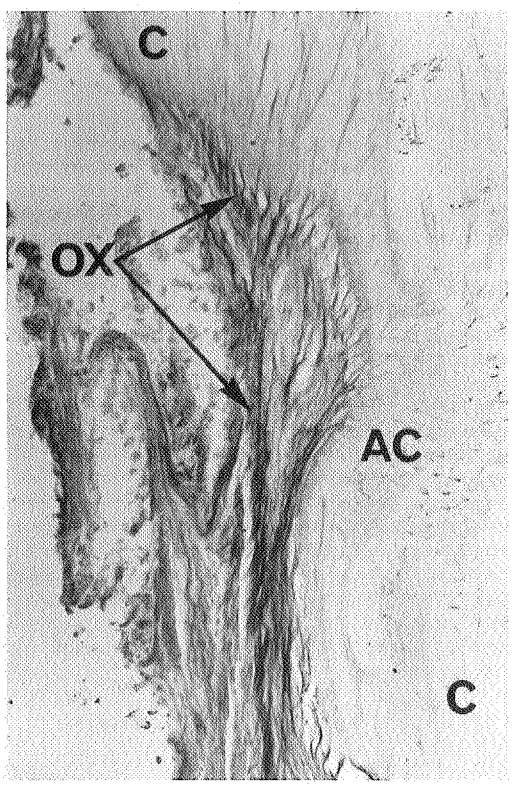


Figure 8 Long oxytalan fibres extending occluso-apically to pass alongside the surface of the hypercementosed tooth. Oxytalan fibre fragments enclosed within the cementum deposit show variable orientation. Mandibular molar, apical region of the mesial root. AC acellular cementum; C cellular cementum; OX oxytalan fibres. Oxone, aldehyde fuchsin, light green. × 250

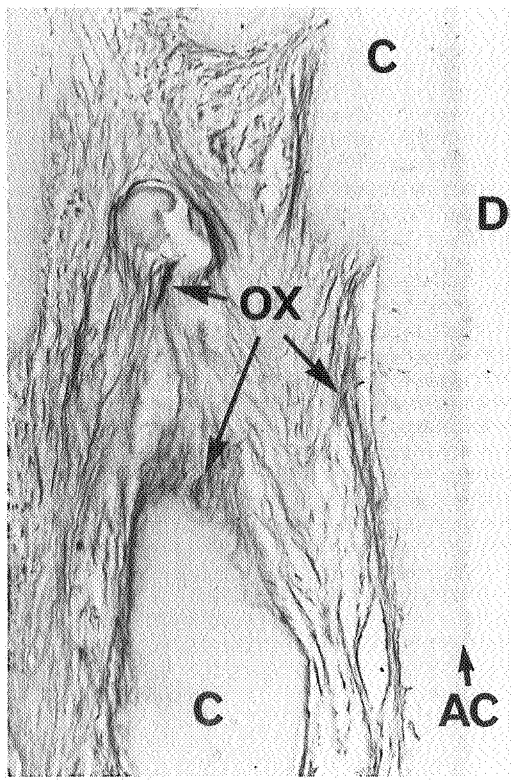


Figure 9 Deep connective tissue pocket containing a predominantly occluso-apical orientation of the oxytalan fibre system. AC acellular cementum; C cellular cementum deposit; D dentine; OX oxytalan fibres. Mandibular right frist molar. Oxone, aldehyde fuchsin, light green. × 225

sections showed an occluso-apical alignment of the fibres whereas other sections contained areas with a horizontal oxytalan fibre direction (Fig. 8).

In various places the cementum surface was irregular due to the presence of many superficial pockets of connective tissue which usually contained prominent collections of oxytalan fibres and blood vessels. The surface openings of similar, but more deeply situated, pockets were also evident. Although the majority of oxytalan fibres in these connective tissues were irregularly dispersed, some fibres showed a generalized occluso-apical alignment conforming to the elongated appearance of the pockets seen in each section. (Fig. 9). Wherever blood vessels were present the oxytalan fibres were commonly associated with their walls.

Occasionally a pocket of connective tissue overlaid the original acellular layer of root cementum and extended through the cementum layers. However, the oxytalan fibres inserted into this cementum passed into the overlying connective tissue with an occluso-apical orientation (Fig. 10). Elsewhere in such sites these fibres exhibited an apico-occlusal or random orientation quite uncharacteristic of the occluso-apical fibre pattern typical of normal teeth.

The multiple layers of cellular cementum contained numerous remnants of oxytalan staining fibres. Many of these fibres were occluso-apically orientated although in some locations, especially in the apical and interradicular portion where the hypercementosis was more irregular, the fibres demonstrated variable orientation from one site to another. In the cervical region cementum was laid down in a more extensive and exaggerated manner to form a collar around each tooth. The adjacent dentine was frequently covered by a double layer of acellular cementum overlaid with multiple strata of cellular cementum exhibiting a distinctive curving pattern of the incremental lines. Patterns of concomitant deposition and resorption were evident at the surface (Fig. 11). Within the cervical portion of this crestal hypercementosis the frequent occurrence of oxytalan fibres was characterized by their angulation towards the occlusal. Many of these fibres entered the overlying connective tissues where they eventually disappeared. Oxytalan fibres were observed to extend horizontally from the unaffected cervical cementum margin into the periodontal tissues where they vanished some 300–400 μm from the root surface. The oxytalan fibre density increased noticeably towards the epithelial attachment where the fibres curved occlusally into the gingival tissues (Fig. 12).

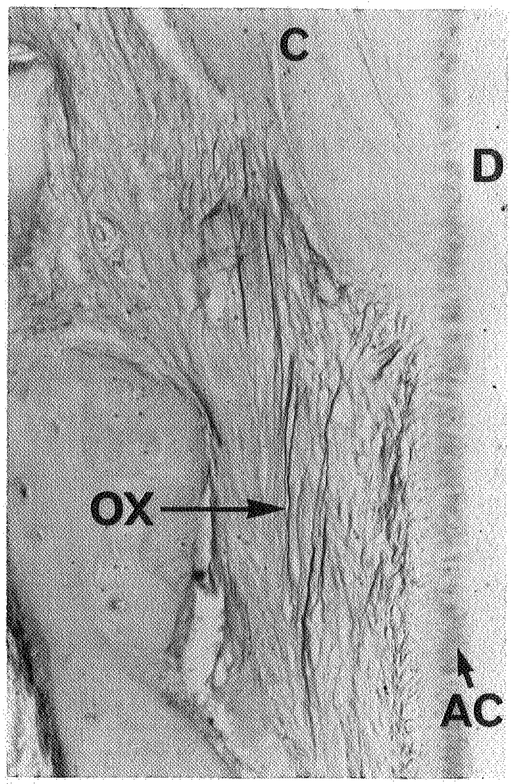


Figure 10 A pocket of connective tissue overlying the original acellular cementum surface and extending through the cellular cementum. Oxytalan fibres have an occluso-apical orientation. AC acellular cementum; C cellular cementum deposit; D dentine; OX oxytalan fibres. Maxillary left first molar. Oxone, aldehyde fuchsin, light green. × 225

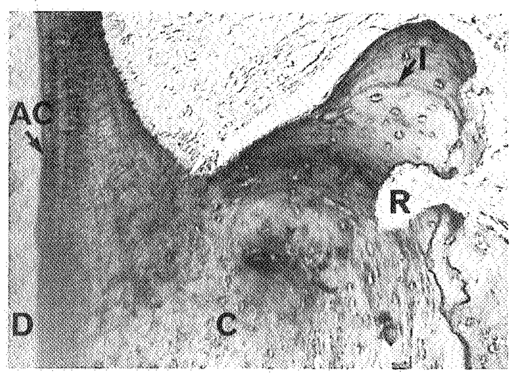


Figure 11 Cervical collar of hypercementosis showing incremental and reversal lines in the cellular cementum which has undergone resorption. Mandibular right molar. AC acellular cementum layers; C cellular cementum; D dentine; I incremental line; R resorption bay. Erlich's haematoxylin. × 200

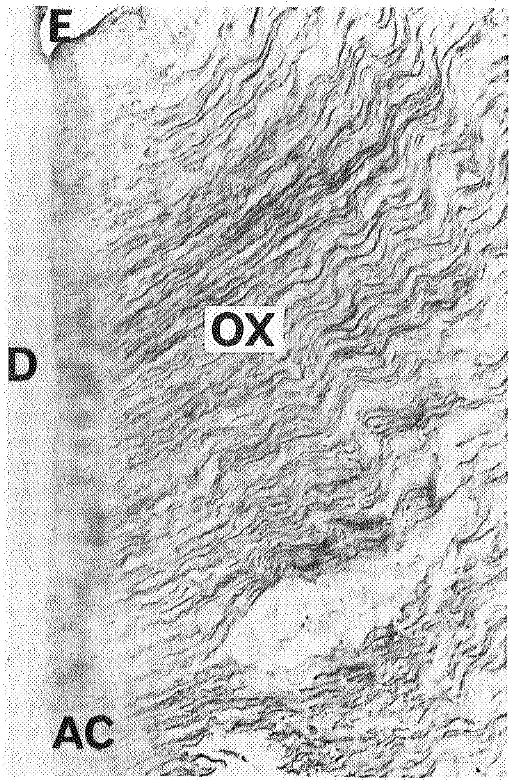


Figure 12 Dense oxytalan fibre arrangement below the epithelial attachment. Mandibular right molar. AC acellular cementum; D dentine; E epithelial attachment region; OX oxytalan fibres. Oxone, aldehyde fuchsin, light green. × 250

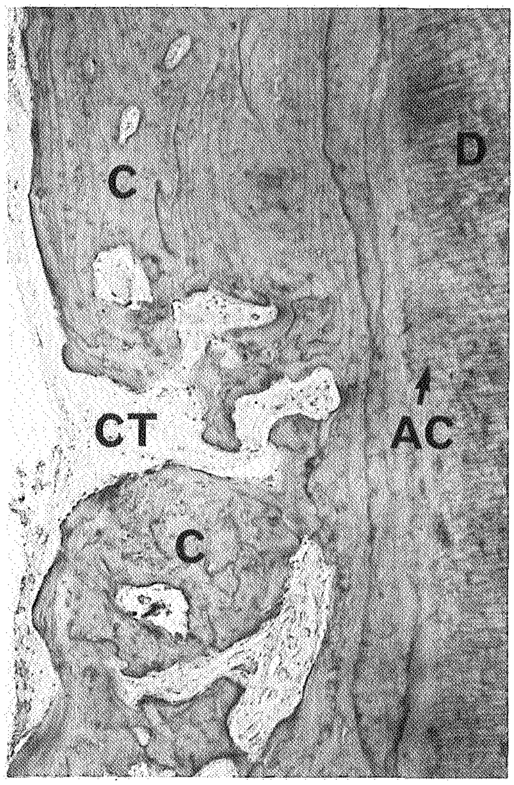


Figure 13 Interradicular region illustrating lamellated and irregular regions of cellular hypercementosis in juxtaposition. Maxillary left molar. AC acellular cementum; C cellular cementum; CT connective tissue; D dentine. Erlich's haematoxylin. × 50

Within the interradicular region the deposition of cellular and acellular cementum was extensive and mostly irregular along the perimeter (Fig. 13). Characteristically, multiple intercommunicating pockets of connective tissue contained abundant but often irregular meshworks of oxytalan fibres. These fibres frequently appeared to extend a considerable distance apically from the adjacent cementum. Blood vessels consistently showed attachment to adjacent oxytalan fibres. Furthermore, the oxytalan meshwork linked adjacent vessels to each other (Fig. 14).

Oxytalan fibres inserted into both acellular or cellular cementum without demonstrating preference for either of these tissues. At various locations the fibres were observed emerging from both types of hypercementosis. However, on large areas of the cementum surfaces oxytalan fibres were located parallel to and in juxtaposition with the cementum without showing convincing evidence of tooth insertion. Furthermore, serial sections through each tooth resulted in occasional slides where large but differing areas of periodontium around the roots were devoid of oxytalan staining fibres.

Although the oxytalan fibre system showed a variable reduction in density and a generalized lack of orientation compared with normal tissues, it nevertheless remained an extensive structure within the periodontium. A systematic examination of a series of unoxidized sections from each tooth proved to be negative for elastic fibres in all areas where oxytalan staining elements were observed.

DISCUSSION

Current text books on dental histology, including Orban (1976), lack information on the microscopical features of the oxytalan fibre system associated with the clinical condition of ankylosis. This condition most frequently affects the deciduous dentition (Darling and Levers, 1973). Unlike the limited term animal study reported by Hurst (1972), the present investigation demonstrates that an extensive oxytalan component persists in the periodontal tissues of human ankylosed molars after many

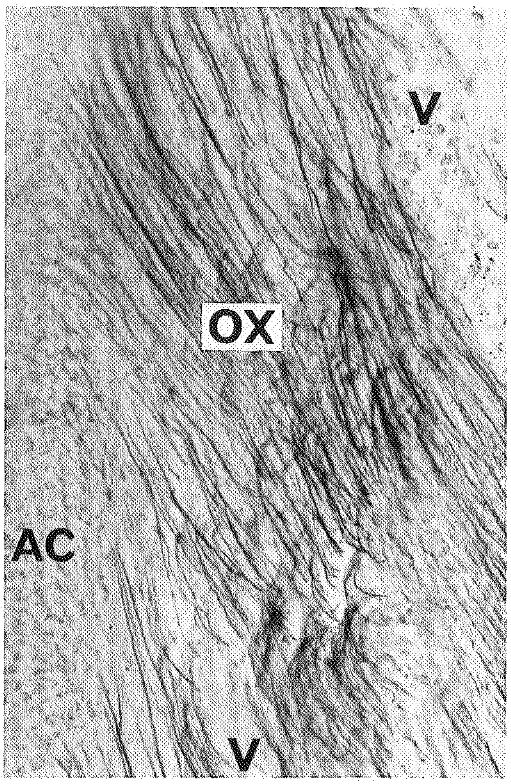


Figure 14 Dense oxytalan fibre meshwork linking vessels in the interradicular region of the right maxillary molar. AC acellular cementum; OX oxytalan fibre meshwork; V vessel. Oxone, aldehyde fuchsin, light green. × 250

years. However, the majority of the oxytalan fibre structures are randomly arranged and fail to show the idiomorphic orientation to either the tooth or adjacent vessels which occurs in the normal periodontal ligament of man and other animals (Sims, 1975a, 1975b, 1976, 1977, 1979; Sampson and Sims, 1977).

Only at the occlusal limit of the cervical cementum did the oxytalan fibres consistently exhibit a typical orientation as they extended from the teeth horizontally into the periodontal tissues or curved occlusally into the free gingivae. This fibre maintenance and distribution in the cervical region may reflect a functional differential between the ankylosed tooth and mobile gingival tissues, where potential gingival flexibility alongside the cementum would be maximal in the region of the epithelial attachment and where the densest concentration of oxytalan fibres always occurs in this pathologic condition. Sims (1977) emphasized that in addition to the vascular interaction provided by the oxytalan fibre system, the meshwork also related the tooth to functional gingival changes. This concept is further substantiated by the present findings.

Despite the lack of tooth mobility, a well-defined oxytalan fibre system persisted, linking the vessels to each other within the remaining connective tissue regions, thus revealing that oxytalan-vascular associations can persist in the absence of tooth oscillation. Reversal of normal oxytalan fibre alignment to an apico-occlusal direction seen in some regions of the periodontium clearly reflects an atypical functional orientation associated with ankylosis, submergence and hypercementosis.

These findings refute Hurst's (1972) conjecture that the oxytalan fibre is needed to provide tooth stability and that its existence depends on natural tooth movement. Findings from the present investigation raise new questions regarding the functional role of the oxytalan fibre meshwork. Although Fullmer (1967), Edwards (1971) and Fullmer et al. (1974) state that oxytalan fibres are found in areas of connective tissue subject to stress, it has been demonstrated (Sims, 1977, 1979) that the oxytalan fibre meshwork persists where vessels of the periodontal ligament traverse the interseptal bone and are protected from the direct action of masticatory loads. Likewise, the system is retained in ankylosis combined with hypercementosis where both fibres and vessels around the roots are enveloped by hard tissues and shielded from direct functional loads.

It is clear that the ankylosis seen in this patient was associated with a marked reduction in the masticatory stress applied to the protected supporting tissues of the first molar teeth. The lack of interdigitation between opposing molars would have minimized occlusal loads during mastication which was, according the patient, restricted to the anterior teeth. Because of the molar positions and their axial inclinations it would be reasonable to conclude that the limited functional stresses they received may have been derived from the adjacent tooth crowns and via distortion of the mandibular corpus and alveolus during mastication.

Fuller et al. (1974) reiterated the view that the oxytalan fibre system is poorly developed in the periodontal ligaments of non-functional teeth. Their opinion is qualified by the present study which reveals that the oxytalan system of all ankylosed teeth was substantial, although it lacked the classic density, orientation and arrangement known to exist in the fully operational human periodontal ligament (Sims, 1975a, 1975b, 1976). Consequently, this investigation establishes that oxytalan fibres are not only found in connective tissues subject to stress (Fullmer, 1958; Fullmer et al., 1974) but also in tissues which are relatively stress protected such as the periodontal structures of submerged teeth.

Since the oxytalan fibre meshwork is such a substantial structure within the periodontal ligament it is essential that its physiological operation should be defined. It is now known that this fibre system is reconstituted during orthodontic tooth movement (Sims, 1975a, 1976). However, no information is available to indicate if orthodontic tooth repositioning impairs the function between the tooth, oxytalan meshwork and the related microvascular system. Knowledge of possible orthodontic modifications to the operation of the microvascular bed, whether they be temporary or permanent, is essential if the clinician is to understand the manner in which his treatment affects the periodontal circulation.

Form and function of the circulatory system are interdependent. Therefore, physiological models of capillary function must be developed and related to the dynamic reality of living systems (Cliff, 1976). Consequently, it is imperative to determine if tooth repositioning has permanent iatrogenic consequences upon blood vessel vitality and the dynamics of tooth support, including transcapillary fluid exchange.

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