

The Interpapillary ligament and oxytalan fibres
in the gingival col of children.

P. J. Roche

P. J. Roche

B.D.S., Syd. Univ.

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Department of Preventive Dentistry,

Faculty of Dentistry,

University of Sydney.

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INTRODUCTION

Attention has been drawn to the supraalveolar collagen fibres of the gingiva as a possible factor contributing to relapse after orthodontic treatment. However there is no general agreement about the existence of one of these fibre groups, namely the interpapillary ligament of the "gingival col".

In 1959 Cohen⁽⁵⁾ described the "gingival col" as a variable depression bounded labially and lingually by the interdental papillae. Three years later Melcher⁽³⁶⁾ described a narrow bundle of densely packed collagen fibres in the col connecting the oral and vestibular mucosa and named this the "interpapillary ligament". Stahl⁽⁵⁰⁾ noted a number of buccolingual fibre bundles rather than one group only in the col, but agreed with Melcher that these fibres might hold the buccal and lingual papillae together. Holmes,⁽³¹⁾ on the other hand, believed that the buccolingual fibre bundles were the circular fibres described by Arnim and Hagerman.⁽²⁾

It has been suggested by Boese⁽⁴⁾ and Edwards⁽⁸⁾ that the presence of oxytalan connective tissue fibres may also be one of the factors contributing to relapse after orthodontic treatment. Oxytalan fibres are a distinct fibre type separable from collagenous, reticular and elastic fibres, but which appear to be related to elastic fibres.⁽¹²⁾

The distribution of oxytalan fibres in the col requires clarification. Fullmer⁽¹³⁾ stated that there is an interproximal zone between the teeth with no oxytalan fibres. Kohl and Zander,⁽³⁴⁾ however, examined the col in Rhesus monkeys and found oxytalan fibres which ran parallel to the dentogingival and circular fibre groups as well as forming a delicate network under the col epithelium.

The purpose of this histological study was to gain further information regarding the presence, or otherwise, of an interpapillary ligament, as described by Melcher,⁽³⁶⁾ and regarding the presence, or otherwise, of oxytalan fibres and their distribution in the gingival col of children.

REVIEW OF THE LITERATURE

The Gingiva

The gingiva can be divided into the free gingiva, the attached gingiva and the interdental papillae. (38)

The free gingiva is that part of the gingiva that surrounds the teeth and is not directly attached to the tooth surface; it forms the outer wall of the gingival sulcus.

The attached gingiva is that part of the gingiva that is firmly attached to the underlying tooth and bone and that is stippled on its oral surface.

The interdental papilla is that part of the gingiva that fills the space between two adjacent teeth and is limited at its base by a line connecting the margin of the gingiva at the centre of one tooth and the centre of the next.

The Col

The col has been described in humans and monkeys by Cohen, (5) Kohl and Zander, (33) Stahl (50) and Holmes. (31)

The gingival col is a variable depression bounded labially and lingually by the interdental papillae, the name being derived from a mountaineering term denoting an irregular depression between two peaks. (5) In the molar region the col

is deeper and the peaks further apart than in the anterior region. Its shape appears to be related to the morphology of the interdental space created by adjacent tooth surfaces. (33)

The buccal and lingual papillae are covered by typical stratified squamous epithelium. The epithelial lining of the col itself in young subjects is a thin unkeratinized layer of cells, sometimes with deep extensions into underlying inflammatory areas. (5) (31) (33)

A clear and definite col formation may be expected to be found in children in the 12 to 15 years age group of this study, where the teeth are in contact and in an early stage of passive eruption.

Fibrous connective tissue

Two basic connective tissue fibre types exist in the interstitial spaces, the collagenous (precollagenous and collagenous) and the elastic (oxytalan and true elastic).

The oxytalan fibre is either a pre-elastic fibre in an arrested state of development or a modified elastic fibre. (39)

Cells and fibres of loose connective tissue are embedded in a ground substance of mucopolysaccharides. (29)

Collagen

Minute collagen fibrils join into larger units of varying lengths and diameters with the fibrils held together by an interfibrillar cementing substance. The length and calibre of a fibre varies with the number of fibrils in its construction.⁽⁴⁰⁾ The diameter of fibres are 1 to 12 microns, and of fibrils 0.3 to 0.5 microns.⁽²⁷⁾ While some fibres remain more or less independent, others form still larger groups or bundles, the size of which are controlled by functional demands, being larger in areas of increased stress. In areas of diminished demands, the calibre of the bundles is reduced correspondingly. The fibre bundle has an undulating path.⁽⁴⁰⁾

A ground substance of mucopolysaccharide nature appears to be associated with collagen synthesis.⁽³⁰⁾ Collagen once formed is relatively inert, but younger collagen has a greater turnover rate than older collagen.⁽³⁾ Increased intra and intermolecular bonding probably occurs with age making collagen more stable both physically and chemically.^{(3) (6) (14) (46)}

Gingival collagen fibres

The function of these fibres appears to be:- (18) (22) (51)

1. To brace the marginal gingiva against the teeth.
2. To provide the rigidity necessary to withstand forces of mastication without being deflected from the tooth surface.
3. To unite the free marginal gingiva with the cementum of the root and adjacent attached gingiva.
4. To inhibit the apical migration of the epithelial attachment.
5. To maintain the teeth in their erupted positions.

Collagen fibre groups of the gingiva

Sicher, (47) (49) Grant et al, (25) Glickman (19) and Goldman et al (22) agree on the existence of four gingival fibre groups. They are the dentogingival, circular, dentoperiosteal and transseptal groups. However they do not all mention the alveologingival group nor the interpapillary ligament.

Dentogingival group (Gingival ligament: Type A and B fibres)

This is the largest group of gingival fibres. (49) (25)

These fibres attach the gingiva to the cementum. The fibre bundles run outward from the cementum into the free and attached gingiva. They usually break up into a meshwork of small bundles and individual fibres interlacing terminally with the fibrous tissue and circular fibres of the gingiva. One group travels occlusally from under the epithelial attachment passing parallel to the crevicular epithelium, another group travels occlusally also but seems to make up the framework of the interproximal gingiva. (21) Melcher (36) claims that the gingival fibres may intermingle with those of the interpapillary ligament, particularly in the papillae.

Circular group (Circular band)

Arnim and Hagerman (2) described a circular band of dense connective tissue lying under the epithelium of the margin of the gingiva. They found that it occupies a large part of the space between the alveolar crest and the gingival margin and mingles with the dentogingival fibres. Some circular fibres originate from the cementum, others from the bone of the alveolar crest.

From the description given, the function of the circular fibres appears to be to maintain the tone of the marginal gingiva in what might be called a "purse string" action around the tooth. However it is difficult to understand how fibres midway between two teeth could fulfill this function. They could scarcely pull towards both teeth at once as their resultant action would be neutralised. These central fibres may have a different function, such as holding together the buccal and lingual papillae.

Dentoperiosteal group (Type C fibres)

On the buccolingual aspect of the tooth this group runs from the cementum at right angles to the tooth over the alveolar crest to join small fibres of the periosteum of alveolar bone. (21)

Transseptal group (Interdental ligament)

This is a prominent and important group which extends from the cementum of one tooth over the alveolar crest to the cementum of neighbouring teeth, binding them together. (23)
It is formed of massive fibre bundles. (41)

Alveologingival group (Fibres of the alveolar crest)

This group has been described as a small group which arises from the alveolar crest and extends into the lamina propria and which is difficult to demonstrate. (25) It has been demonstrated in the rat. (23) (25)

Interpapillary ligament

Melcher (36) described the interpapillary ligament as a narrow bundle of densely packed collagen fibres in the lamina propria of the col connecting the vestibular and oral mucosa. It may mingle with the dentogingival fibres and lies over and at right angles to the transseptal fibres. In the lamina propria the ligament branches. Some of the fibres turn downwards to mingle with the collagen of the attached gingiva. Other fibres run straight on or turn upwards to end in the connective tissue of the papillae. The remaining fibres turn mesially and distally to join similar fibres in adjacent interdental areas. However Melcher did not state on what material he based this detailed description.

Stahl (50) described the fibres of the col from human autopsy specimens and found bundles of collagen fibres which ran over the alveolar crest in a buccolingual direction, joining

the buccal and lingual periosteum. This suggested another anchorage of the interdental tissues besides the dentogingival and transseptal fibres.

Holmes⁽³¹⁾ examined biopsy specimens on the col of young adults but considered that the bundles of fibres seen running in a buccolingual direction were circular fibres only.

There is, therefore, a conflict of views as Melcher and Stahl agreed that a bundle or bundles of collagen fibres joined the oral and vestibular mucosa of the col, whilst Holmes considered that circular fibres only were to be found.

It seems reasonable to suppose that such a fibre group or groups as described by Melcher and Stahl could exist to help to hold the buccal and lingual papillae together against the tooth.

Oxytalan fibres

Oxytalan fibres are a distinct fibre type separable from collagenous, reticular and elastic fibres and which may be immature or specifically modified elastic fibres.⁽¹²⁾

Tissue sections of the periodontium oxidized with peracetic acid, then stained with aldehydefuchsin show many fibres with a brilliant purple colour, which are not collagen fibres.^{(9) (17)}

The aldehyde fuchsin stainable component of oxytalan fibres, but not of elastic fibres, is removed by hyaluronidase, lysozyme and B-glucuronidase in peracetic acid oxidized sections. The aldehyde fuchsin stainable component of oxytalan therefore appears to be of a mucopolysaccharide nature. (11) (30)

Oxytalan fibres have been demonstrated in periodontal membranes of man and in certain animals and in human tendons, ligaments and adventitia of blood vessels. When first seen they may have a diameter of 0.5 microns but may increase to a diameter of 3 microns and may exceed 2 millimeters in length. (9) (10)

Numerous workers, Fullmer, (13) Rannie, (42) Goggins, (20) Kanouse (32) and Edwards, (7) have shown that oxytalan fibres insert into the cementum at the neck of the tooth and travel with the free gingival collagen fibre groups, gradually decreasing in size and terminating varying distances from the tooth. They do not extend to adjacent teeth. Some oxytalan fibres circumscribe the tooth.

The function of oxytalan fibres is uncertain, but it has been suggested that they may give added elasticity and strength to the tissues and prevent overstretching. (7) (14) (42)

The distribution of oxytalan fibres in the col requires clarification. Only one study (34) has been made specifically of the col, and this was in monkeys rather than in man. On the other hand, in other studies (13) (20) few if any oxytalan

fibres were found in the interproximal zone, but it is not clear whether the specimens had a col formation.

A study of the human col therefore seems required.

Elastic fibres

Elastic fibres consist of the protein elastin, which is very resistant to chemical change. They are long and narrow ranging from less than a micron to a few microns thickness. (28)

Elastic fibres are selectively, but not exclusively identified by aldehyde fuchsin. (15)

In contrast to oxytalan fibres, the human gingiva contains only a few elastic fibres which, for the most part, are confined to the walls of blood vessels. (12) (39) (48)

Therefore the aims of this study were

1. To identify the interpapillary ligament in the human gingival col.
2. To identify the regular distribution of oxytalan fibres in the human gingival col.

MATERIALS AND METHODS

Eight biopsy specimens of the interdental gingiva, with the morphological shape of the col, were obtained from six girls and two boys in the 12 to 15 year age range who, except in one case, were to have teeth extracted before orthodontic treatment was started. Three of the specimens were from the molar, four from the bicuspid and one from the canine-bicuspid regions. Of the eight specimens, six were of soft tissue, one was of gingiva attached to a tooth and one was a block specimen with two teeth and alveolar bone intact. The gingiva of each specimen, except the block specimen, was classified as clinically normal.

Surgical removal of the specimens was carried out under local anaesthesia with a sharp scalpel and with careful use of an elevator. Efforts were made to obtain the interdental gingival tissue attached to the extracted tooth or to previously undermined bone of the alveolar crest, but these were unsuccessful except in one case. The block specimen was obtained under general anaesthesia, using a high speed air rotor to cut through the roots of the two teeth concerned and the intervening alveolar bone. Three other specimens, seen to be damaged after surgical removal, were discarded.

Specimens were fixed in neutral buffered formaldehyde for 48 hours, embedded in paraffin wax and sectioned serially

at 10 microns, four in the buccolingual, two in the mesiodistal and two in the occlusal planes. Decal⁽³⁷⁾ (Omega Chemical Corporation, New York) was used to decalcify the two hard tissue specimens, in both of which oxytalan fibres were found, which stained similarly to those in the non-decalcified, soft tissue specimens.

In five specimens all sections cut were mounted but in three cases a step procedure was used.

In order to differentiate oxytalan fibres from elastic fibres and mucopolysaccharide concentrations all specimens were stained in sequence with aldehyde fuchsin preoxidized with acetic acid and followed by Halmi counterstain, with hyaluronidase digestion immediately after preoxidation, and with aldehyde fuchsin and Halmi counterstain only.

The following table⁽¹¹⁾ was used for differentiation, oxytalan fibres being identified by their purple colour when stained with peracetic acid oxidized aldehyde fuchsin and by their lack of colour with the other two stains, as well as by their fibril structure.⁽¹⁶⁾

		Peracetic acid oxidation	Peracetic acid oxidation	Peracetic acid oxidation + hyaluronidase
	Aldehyde fuchsin	+	+	+
	aldehyde fuchsin	aldehyde fuchsin	aldehyde fuchsin	aldehyde fuchsin
Oxytalan fibres	-	P4		P +/-
Elastic fibres	P4		P4	P4
Mucopolysaccharide	P3		P4	P2

P = purple

Results recorded from - to 4 with 4 indicating a strong reaction.

Five of the early specimens were also stained with haematoxylin and eosin, and silver stain, but as it was found that collagen fibre bundles could be clearly seen with the Halmi counterstain alone, this was not carried out in the remaining three specimens.

Peracetic acid was prepared according to the method of Greenspan, (26) and was refrigerated when not in use. Oxidation of specimens was carried out for thirty minutes at room temperature. Aldehyde fuchsin was prepared according to the method of Gomori. (24) It was aged for 72 hours before use and was discarded after one week. The peracetic acid aldehyde fuchsin

Halmi staining reaction was carried out as described by Fullmer and Lillie. (17) Enzymatic digestion with testicular hyaluronidase (British Drug Houses Ltd.) was carried out by the method shown in Fullmer. (11) Silver staining was carried out by the method of Laidlaw. (35)

RESULTS

Three dimensional reconstructions of specimens

A clearer picture of the distribution of collagen and oxytalan fibres was gained by superimposing tracings of some slides from each specimen on each other.

A small mirror was suspended over the microscope and the image of the section was thrown onto a sheet of paper pinned to a wall. The outline, epithelial lining and, where possible, internal details were traced. Each section was re-examined under the microscope at a higher magnification and the pattern of the main fibre bundles was drawn in.

The tracings were then retraced onto clear plastic sheets using different coloured inks to represent gingival outline, collagen fibre bundles, oxytalan fibres and mucopolysaccharide concentrations. Finally the tracings were superimposed on each other using the epithelial attachment, gingival contour, incised gingival borders and, where possible, tooth and alveolar crestal outlines, for orientation.

Specimen R1 with buccolingual plane sections of the UL4-5 interdental area of a male aged 13 $\frac{3}{12}$ years showed buccolingual collagen fibres at a low level under the col. A few irregular oxytalan fibres were seen in one area only.

Specimen R2 with mesiodistal plane sections of the LL4-5 interdental area of a female aged 13 years showed a regular pattern of numerous small buccolingual collagen fibres seen end on under the col. Some of these rose into the buccal and lingual papillae, whilst others sank to intermesh with fibres originating from alveolar bone. Other fibre bundles, probably of the transseptal group, were seen to pass at right angles under the buccolingual fibres. Oxytalan fibres were present around the lower buccolingual collagen fibres.

Specimen R3 with occlusal plane sections of the LR6-7, interdental area of a female aged 12 ⁵/₁₂ years showed extremely dense buccolingual collagen fibres at a low level joining the buccal and lingual papillae. Some fibres rose to terminate in the peaks of the buccal and lingual papillae. Dense irregular concentrations of oxytalan fibres were present at the confluence of the buccolingual, alveologingival and dentogingival collagen fibre groups whilst elsewhere oxytalan fibres travelled with and occasionally at right angles to the collagen fibres.

Specimen R4 with buccolingual plane sections of the UR6-7 interdental area of a female aged 12 $\frac{5}{12}$ years showed buccolingual collagen fibres which joined the lamina propria at a low level. Some of the fibres rose to intermesh with fibres of other groups in plexi in the buccal and lingual papillae. Oxytalan fibres were numerous at the interweaving of collagen fibres in the plexi of the buccal and lingual papillae and a few oxytalan fibres travelled with the buccolingual collagen fibres.

Specimen R5 with buccolingual plane sections of the UR6-7 interdental area of a female aged 13 $\frac{9}{12}$ years showed numerous small buccolingual collagen fibres joining the buccal and lingual lamina propria at a low level. Some of the higher fibres rose towards the peaks of the buccal and lingual papillae. Numerous oxytalan fibres were present at one end of the interdental area, some travelling with the buccolingual collagen fibres. Small concentrations of oxytalan fibres were present in the middle of the col as well as a large concentration apparently associated with the dentogingival collagen group.

Specimen R6 with mesiodistal plane sections of the UL4-5 interdental area of a female aged 13 years showed no clear collagen fibre pattern. Nor were oxytalan fibres found.

Specimen R10 with buccolingual plane sections of the UL3-4 interdental area of a male aged 15 years was a decalcified block specimen. Collagen fibres joined the buccal and lingual papillae and lamina propria but in a very irregular fashion. They emanated from a large fibre plexus in the middle of the col. Collagen fibres also rose from this plexus to the col lining. In one section some collagen fibres seen end on could have been transseptal fibres. Oxytalan fibres were found in part of the central collagen fibre plexus as well as accompanying buccolingual collagen fibres in the buccal papilla.

Specimen R11 with occlusal plane sections of the UL4-5 interdental area of a female aged 14 $\frac{1}{2}$ years showed buccolingual collagen fibres joining the buccal and lingual papillae at a low level. At a higher level dentogingival collagen fibres entered the col and at a higher level still circular fibres were seen close to the tooth. A few oxytalan fibres only were associated with the dentogingival collagen fibres.

DISCUSSION

The Interpapillary Ligament

Out of eight specimens only one R3, Figures 6 to 9, conformed to Melcher's description of a narrow densely packed bundle of collagen fibres in the col joining the oral and vestibular mucosa.

Of the remainder two specimens, R1 and R11, showed some fibre bundles, though not dense, passing buccolingually under the col, two specimens R2, Figures 1 to 5, and R5 showed numerous small bundles passing buccolingually under the col, one specimen R4 showed fibre bundles passing buccolingually across the col but joining fibre plexi in the buccal and lingual papillae, one specimen R10, Figures 14 and 15, showed buccolingual fibre bundles across the col but emanating from a central fibre plexus and one specimen R6, Figure 13, showed no clear orientation of the fibre bundles.

Therefore findings in this study did not show that a discrete interpapillary ligament or narrow dense band of collagen fibres, as described by Melcher,⁽³⁶⁾ always exists but was more often in accordance with Stahl's⁽⁵⁰⁾ description of a number of buccolingual fibre bundles, sometimes quite widespread.

However, in seven out of the eight specimens a buccolingual collagen fibre system, varying considerably in

density and distribution from specimen to specimen, joined the oral and vestibular mucosa.

The variability in the density and distribution of the buccolingual collagen fibre bundles of the subjects in this study may be explained by the varied morphology of the interdental spaces. In the case of teeth which had only just come into occlusion gingival fibre bundles might still be in the process of altering their orientation and density to adapt to newly experienced stresses.

Circular fibres, when occasionally seen, were small and close to the tooth and at a higher level than the buccolingual fibre bundles. The morphology of the col, in which Holmes⁽³¹⁾ described circular fibres, may have been different owing to further passive eruption of the teeth in his older subjects.

Collagen fibre bundles running in a mesiodistal direction under the buccolingual fibre bundles were occasionally seen, Figures 5 and 14, but not as a dense continuous group joining two teeth. This is in agreement with Stahl,⁽⁵⁰⁾ who also found what he considered to be transseptal fibres, but, from his own description, they did not form a dense group. He also referred to the buccolingual fibres as a "crestal periosteum", in which case a dense fibre group could scarcely pass at right angles under them.

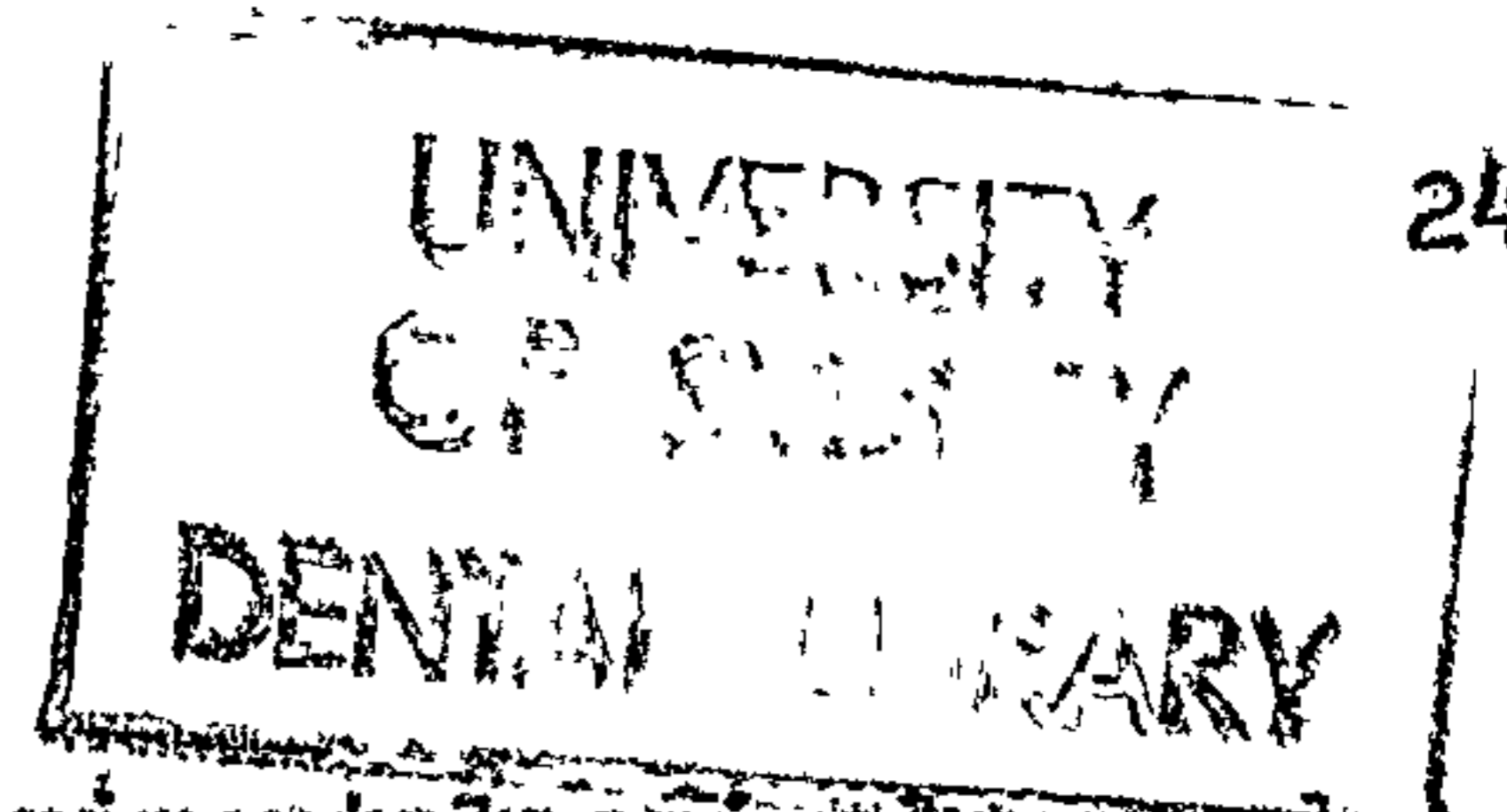
Oxytalan fibres

Whilst oxytalan fibres were frequently seen, findings in this study did not show that there was a regular distribution of them with collagen fibre groups, nor that there was an oxytalan network as described by Kohl and Zander.⁽³⁴⁾ There were, in fact, great variations in density and distribution of oxytalan fibres from specimen to specimen.

In some places, Figures 9 and 12, oxytalan fibres travelled with collagen fibre bundles, in others, Figures 10 and 12, they passed at right angles to the collagen fibre bundles, and in others at the junction of different collagen fibre groups; Figure 8, there were sometimes dense irregular concentrations.

Oxytalan fibres, passing at right angles to the collagen fibre bundles, have been described in the periodontal membrane by Fullmer⁽¹³⁾ and Rannie,⁽⁴²⁾ but not previously in the gingiva. Nor have dense irregular concentrations of oxytalan fibres been described previously.

There may be several reasons for the differences between the descriptions of the previous workers, Fullmer,⁽¹³⁾ Rannie,⁽⁴²⁾ Goggins,⁽²⁰⁾ and Edwards⁽⁷⁾ and the findings in this study. The interdental papillae examined may not have had the morphologic shape of the col, the subjects may not have been in the age group of those in this study, and there may have been differences in



the collagenous fibre systems of the experimental animals used compared with human subjects.

In their study of the col of monkeys, Kohl and Zander⁽³⁴⁾ described a regular arrangement of oxytalan fibres. They examined aldehyde fuchsin stained sections preoxidized with peracetic acid and did not attempt to differentiate oxytalan fibres from possible mucopolysaccharide concentrations by interposing hyaluronidase digestion between the peracetic acid oxidation and aldehyde fuchsin stains, as was done in this study. It is possible therefore that some mucopolysaccharide concentrations were incorrectly recognised as oxytalan fibres. Whilst in this study, little or only moderate amounts of mucopolysaccharide were occasionally found, one specimen, Figure 13, showed rich widespread concentrations.

Kohl and Zander⁽³⁴⁾ confirmed Fullmer's⁽¹⁴⁾ observation that whilst oxytalan fibres were denatured in inflammatory areas, they were more resistant to this process than were collagen fibres. In the present study it was assumed that if oxytalan fibres were denatured they would fail to stain as typical oxytalan fibres with the three differential stains used.

Function of oxytalan fibres

It has been suggested that, because of their staining reactions and distribution, oxytalan fibres are related to elastic fibres and may impart an elasticity to the tissues.⁽¹⁴⁾ It has also been suggested that oxytalan fibres may prevent overstretching of the tissues in certain areas⁽⁷⁾ and that the weaving of oxytalan fibres between collagen fibres may give added strength.⁽⁴²⁾ It seems more likely that the strength of the tissues is provided primarily by the collagen fibres and that the main function of the fibres is to impart elasticity.

This concept of the oxytalan fibres is supported by their concentrations and distribution in this study, particularly at the junction of different collagen fibre groups which would pull in different directions. The largest concentrations were found associated with very dense collagen fibre bundles in a specimen from the lower molar region where the greatest forces to the periodontal ligament and gingival fibres would be exerted as a result of mastication. Weaving of oxytalan fibres between collagen fibres was also seen. This is in agreement with Rannie⁽⁴²⁾ who stated that there is a difference in the number of oxytalan fibres in buccal as opposed to incisor teeth of monkeys.

Supraalveolar fibres and orthodontic relapse

Orthodontic relapse may be regarded as a return of teeth to a previous state less favorable than one recently obtained, Adamson.⁽¹⁾ Experimental rotation of teeth has shown that some gingival collagen fibre bundles remain displaced and stretched long after tooth to bone periodontal fibres have rearranged.^{(7) (43) (44) (45)}

Therefore relapse of rotated teeth after retention appears to be caused by a "recoil" of the displaced and stretched gingival and transseptal fibres. Surgical intervention, which disrupted the supraalveolar fibres, has been shown to decrease relapse after orthodontic tooth movement.^{(4) (8) (52) (53)}

A buccolingual collagen fibre system in the col would therefore play its part in any relapse resulting from recoil of the supraalveolar collagen fibres, which have been described as a tough, tenacious, tendinous-like band of tissue surrounding the teeth.⁽⁵¹⁾

The effectiveness of early correction, overrotation^{(43) (44)} and prolonged retention in achieving an increased stability of rotated teeth has been questioned.⁽⁴⁾ Edwards⁽⁸⁾ has shown that a relatively simple surgical technique is effective in decreasing orthodontic relapse: a radical gingivectomy as carried out by Thomson⁽⁵¹⁾ is not necessary. This study suggests that where a dense or extensive buccolingual collagen fibre group is present,

there may be a correspondingly less dense transseptal fibre group. This would be fortunate, as where teeth are in contact, access with a scalpel to the insertion of the transseptal fibres would be rather difficult. The effectiveness of the surgery may result mainly from the sectioning of the dentogingival collagen fibres which allows the displaced gingival tissue to return to its original position before reattaching to the tooth.

It has also been suggested by Boese⁽⁴⁾ and Edwards⁽⁸⁾ that the elastic-like oxytalan fibres may play an important part in relapse. Boese⁽⁴⁾ went so far as to claim that displaced oxytalan fibres were the primary etiologic factor in relapse. Oxytalan fibres were found in sufficiently large concentrations in this study to constitute a potential condition contributing to relapse.

Need for further studies

It may be expected that relapse tendency after orthodontic treatment will be greatest in those cases where very dense concentrations of collagen fibre bundles and oxytalan fibres are present. This study suggests that there may be a relationship between the densities of oxytalan fibres and the collagen fibre bundles. Where collagen bundles are subjected to increased functional demands, they may respond to the increased stress by becoming very large. In such cases dense concentrations of elastic-like oxytalan fibres may also form to impart resiliency to the tissues.

In these cases surgical intervention to prevent relapse, particularly after orthodontic rotation of the teeth, may be beneficial, if not essential. It would be helpful if such cases could be recognised and if simple surgery could be carried out routinely on completion of orthodontic treatment.

Further histological studies are needed to try to relate the histological picture, and particularly the density and distribution of the collagen bundles and oxytalan fibres, to the masticatory forces experienced by the teeth. It might eventually be possible to envisage the histological picture of the gingival fibres from the clinical picture. By taking into account factors such as type of malocclusion, strength of masticatory muscles,

X-ray evidence of bone density and age of the patient, the orthodontist would then be in a better position to decide whether surgical intervention was needed.

SUMMARY

A review of the literature showed a disagreement regarding the existence of the so-called interpapillary ligament as well as regarding the numbers and distribution of oxytalan fibres in the human gingival col.

In order to try to test for the interpapillary ligament and to examine oxytalan fibre distribution eight biopsy specimens with the morphologic shape of the col were obtained from the molar, bicuspid and canine-bicuspid regions from children in the twelve to fifteen year age group.

Of the eight specimens, six were of soft tissue, one consisted of gingiva attached to a tooth, and one was a block specimen with two teeth and alveolar bone intact. The gingiva of all specimens, except the block specimen, were judged clinically to be healthy. The specimens were fixed, decalcified and sectioned in the buccolingual, mesiodistal and occlusal planes.

A differential staining procedure was used to identify oxytalan and elastic fibres and mucopolysaccharide concentrations. All specimens were stained with oxidized aldehyde fuchsin with Halmi counterstain, with unoxidized aldehyde fuchsin with Halmi counterstain, and with testicular hyaluronidase digestion interposed between oxidation and the aldehyde fuchsin stain followed by the Halmi stain. Some specimens were also stained with haematoxylin and eosin, and silver stain.

In order to study the pattern of distribution of collagen fibre bundles and oxytalan fibres throughout the specimens, three dimensional reconstructions of the interdental gingiva were made in the mesiodistal, buccolingual and occlusal planes by superimposing transparent sheets on which tracings of slides had been made.

Certain conclusions were then drawn regarding the existence of the interpapillary ligament and the numbers and distribution of oxytalan fibres in the col and the need for further studies.

CONCLUSIONS

1. A discrete interpapillary ligament, as described by Melcher, was not found generally to exist, but the majority of specimens showed buccolingual collagen fibre bundles of very variable density and distribution which joined the oral and vestibular mucosa.
2. Oxytalan fibres were frequently found in the interdental papillae but there was no regular pattern. They varied from a few fibres only to dense irregular concentrations. They frequently travelled with collagen fibre bundles and in some cases passed at right angles to them. This irregular arrangement suggested that they may give added elasticity to the tissues in certain stress areas, particularly where different gingival collagen fibre groups intermesh.

BIBLIOGRAPHY

1. Adamson, K.T. - Relapse in orthodontics. *Int. Dent. J.*,
8 : 2, 304-305 (June) 1958.
2. Arnim, S.S., and Hagerman, D.A. - The connective tissue
fibers of the marginal gingiva. *J.A.D.A.*
47 : 3, 271-281 (Sept.) 1953.
3. Benjamin, S.D. - Current concepts of connective tissue.
Periodontal Abstracts, 13 : 3, 115-118 (Sept.) 1965.
4. Boese, L.R. - Increased stability of orthodontically rotated
teeth following gingivectomy (M.S.D. Thesis).
Abstr., Am. J. Orthodont., 55 : 5, 527-529
(May) 1969.
5. Cohen, B. - Morphological factors in the pathogenesis of
periodontal disease. *Brit. Dent. J.*, 107 : 1 and 2,
31-39 (July 7 and 21) 1959.
6. Eastee, J.E. - Insoluble collagen. p.14-19. (In the
Mechanisms of tooth support - A symposium. Bristol,
John Wright and Sons Ltd., 1967.)
7. Edwards, J.G. - A study of the periodontium during orthodontic
rotation of teeth. *Am. J. Orthodont.*, 54 : 6,
441-461 (June) 1968.
8. Edwards, J.G. - A surgical procedure to eliminate rotational
relapse. *Am. J. Orthodont.*, 57 : 1, 35-46 (Jan.) 1970.

9. Fullmer, H.M. - Differential staining of connective tissue fibers in areas of stress. *Science*, 127 : 3308, 1240 (May 23) 1958.
10. Fullmer, H.M. - Observations on the development of oxytalan fibers in the periodontium of man. *J. Dent. Res.*, 38 : 3, 510-518 (May - June) 1959.
11. Fullmer, H.M. - Effect of peracetic acid on the enzymatic digestion of various mucopolysaccharides ; reversal of the PAS staining reaction of mucin. *J. Histochem. Cytochem.*, 8 : 2, 113-121 (Mar.) 1960.
12. Fullmer, H.M. - A comparative histochemical study of elastic, pre-elastic and oxytalan connective tissue fibers. *J. Histochem. Cytochem.*, 8 : 4, 290-295 (July) 1960.
13. Fullmer, H.M. - A histochemical study of periodontal disease in the maxillary alveolar processes of 135 autopsies. *J. Periodont.*, 32 : 3, 206-218 (July) 1961.
14. Fullmer, H.M. - A critique of normal connective tissues of the periodontium and some alterations with periodontal disease. *J. Dent. Res.*, 41 : 1 Supplement, 223-229 (Jan. - Feb.) 1962.
15. Fullmer, H.M. - The use of histochemistry in Oral Histology. p.510. (In Provenza, D.V. - *Oral Histology*. Philadelphia, J.B. Lippincott Co., 1964).

16. Fullmer, H.M. - The development of oxytalan fibres, p.72-73.
(In The Mechanisms of tooth support - a symposium.
Bristol, John Wright and Sons Ltd., 1967).
17. Fullmer, H.M., and Lillie, R.D. - The oxytalan fiber : a
previously undescribed connective tissue fiber.
J. Histochem. Cytochem., 6 : 6, 425-430 (Nov.) 1958.
18. Glickman, I. - Clinical periodontology. Philadelphia,
W. B. Saunders, 3rd ed, 1964, (p. 11-12).
19. Ibid. - (p. 12-13).
20. Goggins, J.F. - The distribution of oxytalan connective
tissue fibers in the periodontal ligaments of
deciduous teeth. Periodontics, 4 : 4, 182-186
(July - Aug.) 1966.
21. Goldman, H.M. - The topography and role of the gingival
fibers. J. Dent. Res., 30 : 3, 331-336 (June) 1951.
22. Goldman, H.M., Schluger, S., Fox, L., and Cohen, D.W., eds. -
Periodontal therapy. St. Louis, The C.V. Mosby Co.,
3rd ed., 1964. (p. 37-38).
23. Ibid. - (p. 39).
24. Gomori, G. - p.364. In Lillie, R.D. - Histopathologic
technic and practical histochemistry. New York,
Blakiston, 2nd ed. 1954.
25. Grant, D., Stern, I.B., and Everett, F.G., eds. - Orban's
periodontics. St. Louis, The C. V. Mosby Co.,
3rd ed., 1968. (p. 19-23).

26. Greenspan, F.P. - p. 310. In Lillie, R.D. - Histopathologic technic and practical histochemistry. New York, Blakiston, 2nd ed., 1954.
27. Ham, A.W. - Histology. Philadelphia, J.B. Lippincott Co., 6th ed., 1969. (p. 209).
28. Ibid. - (p. 214).
29. Ibid. - (p. 214-215).
30. Harris, R., and Griffin, C.J. - Aldehyde fuchsin-halmi reaction in fibres of the human dental pulp. Arch. Oral Biol., 11 : 7, 649-658 (July) 1966.
31. Holmes, C.H. - Morphology of the interdental papillae. J. Periodont., 36 : 6, 455-460 (Nov. - Dec.) 1965.
32. Kanouse, M.C. - Oxytalan fibers in the periodontium of ascorbic acid-deficient guinea pigs. J. Dent. Res., 45 : 2, 311-314 (Mar. - Apr.) 1966.
33. Kohl, T.J., and Zander, H.A. - Morphology of the interdental gingival tissues. Oral Surg., Oral Med., and Oral Path., 14 : 3, 287-295 (Mar.) 1961.
34. Kohl, T.J., and Zander, H.A. - Fibres conjonctives "oxytalan" dans le tissu gingival interdentaire. Parodontol., 16 : 1, 23-30 (Apr.) 1962.
35. Laidlaw, G.F. - p.267. In Gurr, E. - Staining animal tissues, practical and theoretical. London, Leonard Hill (Books) Ltd., 1962.

36. Melcher, A.H. - The interpapillary ligament. D. Practitioner and D. Record, 12 : 12, 461-462 (Aug.) 1962.
37. Orams, H.J. - Enamel prism structure. Austral. D.J., 13 : 6, 451 (Dec.) 1968.
38. Orban, B. - Clinical and histological study of the surface characteristics of the gingiva. J. Oral Surg., Oral Med., and Oral Path., 1 : 9, 827-841 (Sept.) 1948.
39. Provenza, D.V. - Oral Histology. Philadelphia, J.B. Lippincott Co., 1964. (p.63).
40. Ibid. - (p. 330).
41. Ibid. - (p. 333).
42. Rannie, I. - Observations on the oxytalan fibre of the periodontal membrane. Tr. European Orthodont. Soc., 39 : 127-133, disc., 133-136 (June) 1963.
43. Reitan, K. - Tissue rearrangement during retention of orthodontically rotated teeth. Angle orthodont., 29 : 2, 105-113 (April) 1959.
44. Reitan, K. - Tissue behaviour during orthodontic tooth movement. Am. J. Orthodont., 46 : 12, 881-900 (Dec.) 1960.
45. Reitan, K. - Clinical and histological observations on tooth movement during and after orthodontic treatment. Am. J. Orthodont., 53 : 10, 721-745 (Oct.) 1967.

46. Rigby, B.J., Bloch, B., and Mason, P. - The behaviour of collagen in diseases affecting connective tissues. Med. J. of Australia, 1 : 2, 46-51 (Jan. 8). 1966.
47. Sicher, H. - Orban's Oral Histology and Embryology. St. Louis, The C.V. Mosby Co., 6th. ed., 1966. (p. 181).
48. Ibid. - (p. 222).
49. Ibid. - (p. 223).
50. Stahl, S.S. - Morphology and healing pattern of human interdental gingivae. J.A.D.A., 67 : 1, 48-53, (July) 1963.
51. Thompson, H.E. - Orthodontic relapses analyzed in a study of connective tissue fibers. Am. J. Orthodont., 45 : 2, 93-109 (Feb.). 1959.
52. Thompson, H.E., Myers, H.I., Waterman, J.M., and Flanagan, V.D. - Preliminary macroscopic observations concerning the potentiality of supra-alveolar collagenous fibers in orthodontics. Am. J. Orthodont., 44 : 7, 485-497 (July) 1958.
53. Wiser, G.M. - Resection of the supra-alveolar fibers and the retention of orthodontically rotated teeth. Abstr., Am. J. Orthodont., 52 : 11, 855-856 (Nov.) 1966.

PHOTOMICROGRAPHS

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MESIO-DISTAL

COL LINING



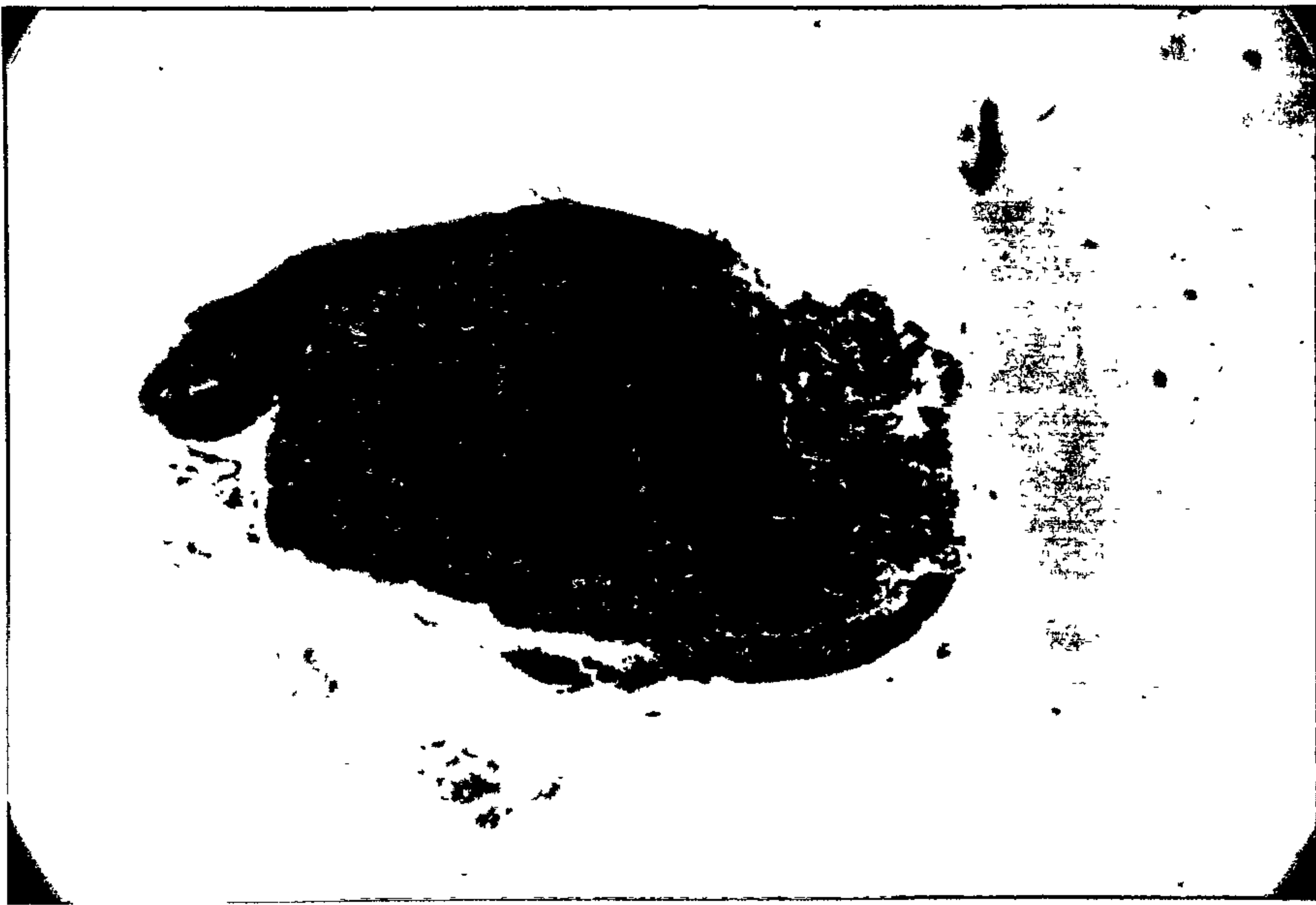
100x

ALVEOLAR CREST

MESIO-DISTAL

MESIO-DISTAL

COL LINING



500x

ALVEOLAR CREST

MESIO-DISTAL

Figure 1 Slide 31 (R2) x 18 M4-5

Haematoxylin and eosin;
mesiodistal plane

The whole section from the col region is visible. The next four photomicrographs are higher powered views of the same specimen on consecutive slides and illustrate the differential staining cycle of specimens R1, R2, R3, R4 and R5.

Figure 2 Slide 32 (R2) x 60

Peracetic acid, aldehyde
fuchsin with Halmi counterstain

This is a higher powered view of the middle of the same specimen as shown in Figure 1. The differential staining indicates that the purple stains, although diffuse, are oxytalan fibres associated with the lower buccolingual collagen bundles.

Figure 3 Slide 33 (R2) x 60

Laidlaw silver stain

Higher powered view of the middle of the same specimen as seen in Figure 1. Numerous buccolingual collagen fibre bundles are seen end on. The darkstained basement membrane of the col lining is just visible.

Figure 4 Slide 34 (R2) x 60

Peracetic acid, testicular hyaluronidase, aldehyde fuchsin with Halmi counterstain

Higher powered view of the middle of the same specimen as in Figure 1. The purple stains of the oxidized aldehyde fuchsin stains, as seen in Figure 2 have been removed by enzymatic digestion, indicating that those purple stains are either oxytalan fibres or mucopolysaccharide concentrations, but not elastic fibres.

Numerous small buccolingual collagen fibre bundles are seen end on in the middle of the section. There are clawlike projections of the col into underlying inflammatory areas.

COL LINING

MESIO-DISTAL



MESIO-DISTAL

ALVEOLAR CREST

100 μ

Figure 5

Slide 35 (R2) x 60

aldehyde fuchsin with Halmi counterstain

Higher powered view of the middle of the same specimen as in Figure 1. Any mucopolysaccharide concentrations or elastic fibres would be indicated by purple stains. This indicates that the purple stains of Figure 2, and similarly stained slides are oxytalan fibres. This photomicrograph may be compared with one from a different specimen

Figure 13 (R6) where dense mucopolysaccharide concentrations were seen. Numerous small collagen fibre bundles are seen end on in the middle of the section at A. Collagen fibre bundles passing mesiodistally under them at B may belong to the transseptal group. On the left at C rising fibre bundles appear to belong to the dentogingival group.

MESIAL

LINGUAL



BUCCAL

DISTAL

500 μ

MESIAL

LINGUAL



BUCCAL

DISTAL

500 μ

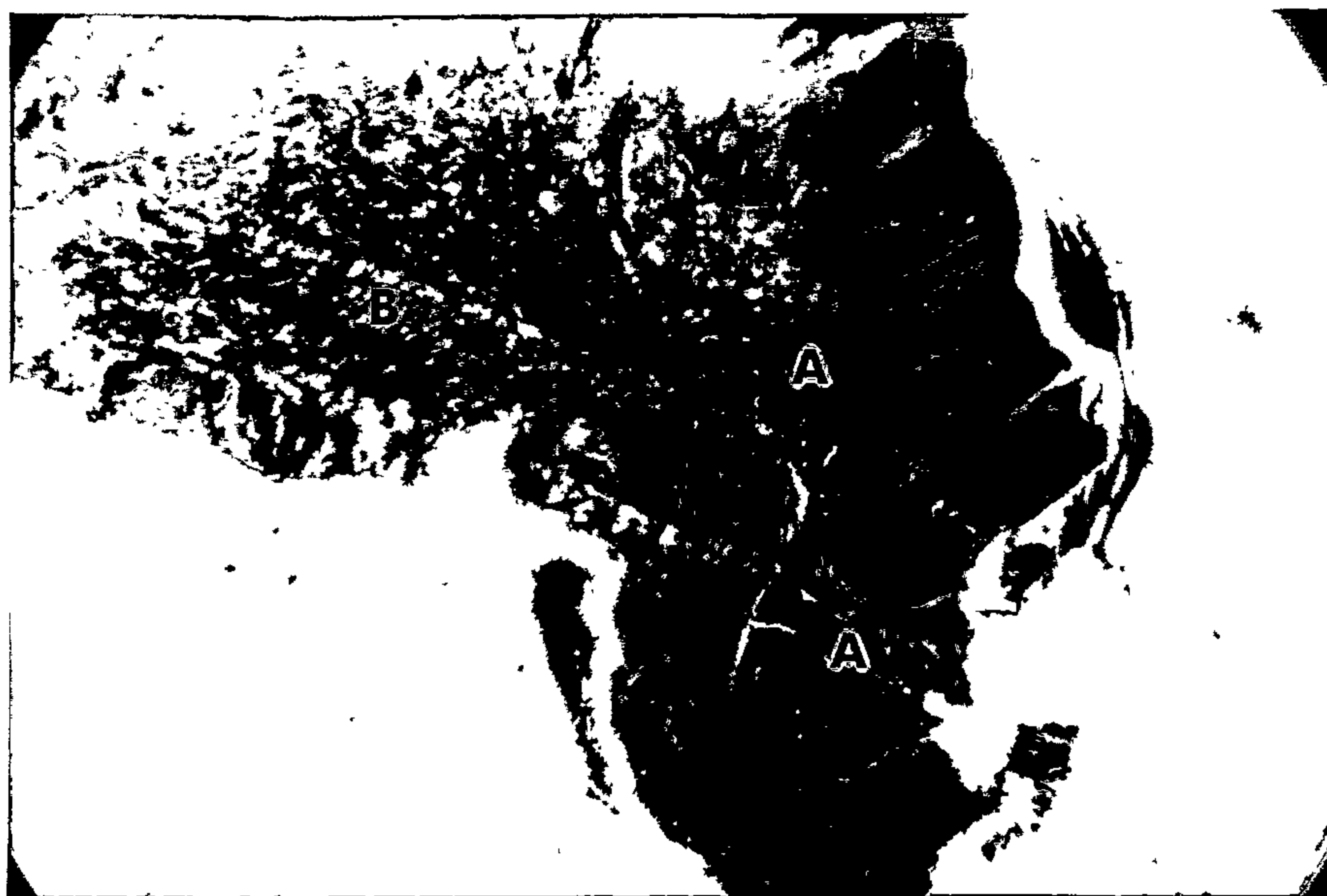
Figure 6 Slide 8 (R3) x 18, LR6-7, occlusal plane, peracetic acid, aldehyde fuchsin with Halmi counterstain

This and the next two photomicrographs, that is Figures 6, 7 and 8, are adjoining and overlapping areas from the same section at the base of the dental papilla. The outlined area is seen at higher magnification in Figure 9. There is extensive inflammation of the mesial slope of the interdental gingiva at A and of the lingual papilla at B. Dense buccolingual collagen fibre bundles at C pass across the section with oxytalan fibres travelling with and between them.

Figure 7 Slide 8 (R3) x 18, LR6-7, occlusal plane, peracetic acid, aldehyde fuchsin with Halmi counterstain,

This is an area overlapping and adjoining Figure 6. The dense buccolingual collagen fibre bundles at A radiate into the buccal papilla at B and intermesh with dense rising alveologingival collagen fibre bundles seen at C. There is part of a large dense concentration of oxytalan fibres at D. Claw like epithelial extensions of the col lining extend into the underlying inflammatory area.

MESIAL



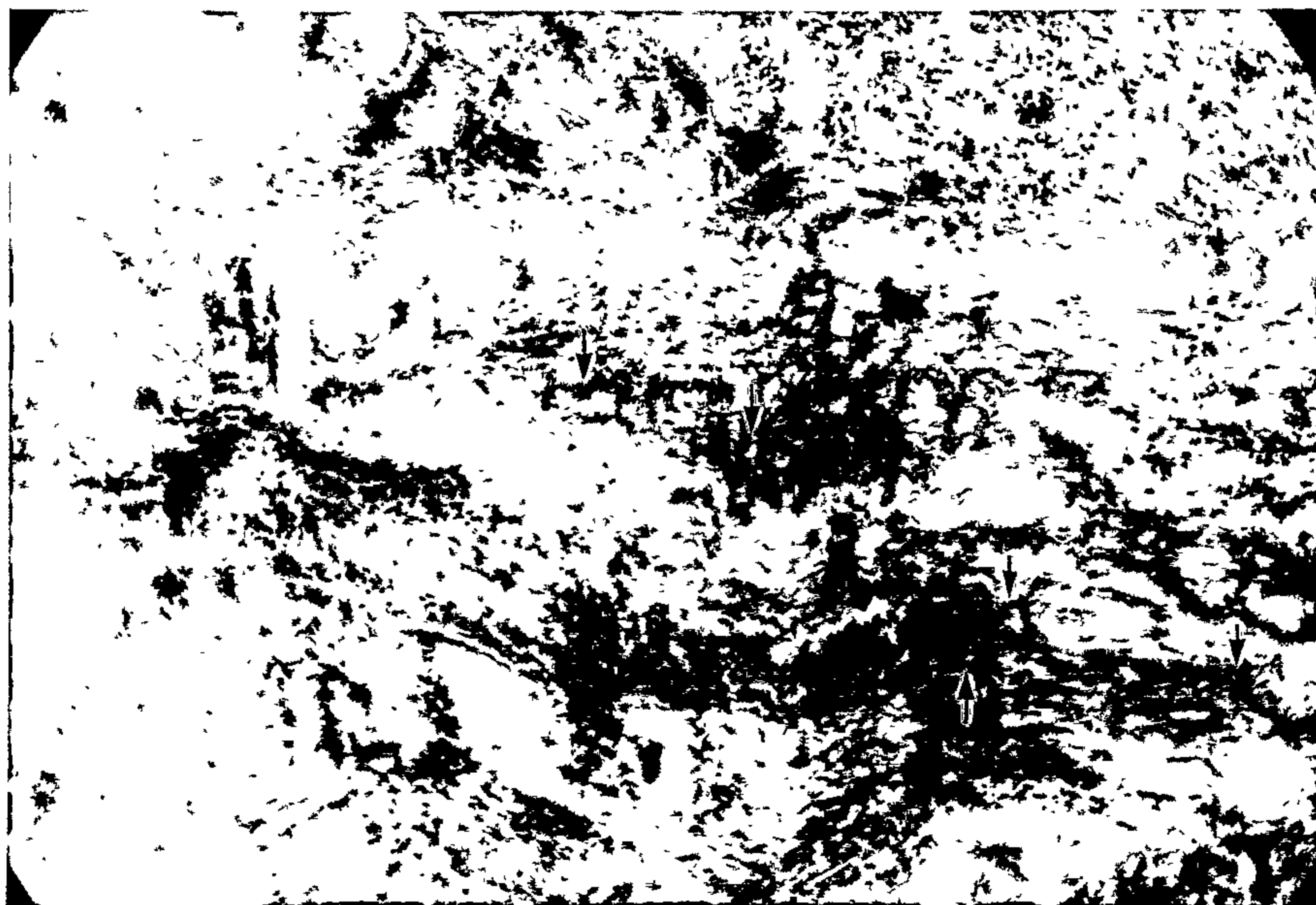
LINGUAL

BUCCAL

DISTAL

500 μ

MESIAL



LINGUAL

BUCCAL

DISTAL

100 μ

Figure 8 Slide 8 (R3) x 18, LR 6-7, occlusal plane, peracetic acid, aldehyde fuchsin with Halmi counterstain.

This is an area adjoining Figure 7. Dense alveologingival collagen fibre bundles are seen end on on the right at A. An extensive concentration of oxytalan fibres at B, part of which is seen in Figure 7, is present at the confluence of the buccolingual, alveologingival and dentogingival collagen fibre groups.

Figure 9 Slide 8 (R3) x 60, LR 6-7, occlusal plane, peracetic acid, aldehyde fuchsin with Halmi counterstain.

This is a higher powered view of the dense buccolingual collagen fibre bundles in the outlined area of Figure 6. Purple oxytalan fibres, indicated by arrows, can be seen travelling with them.

MESIAL

LINGUAL



BUCCAL

DISTAL

50 μ

Figure 10 Slide 20 (R3) x 125 LR 6-7, occlusal plane,
peracetic acid, aldehyde fuchsin with Halmi counterstain.

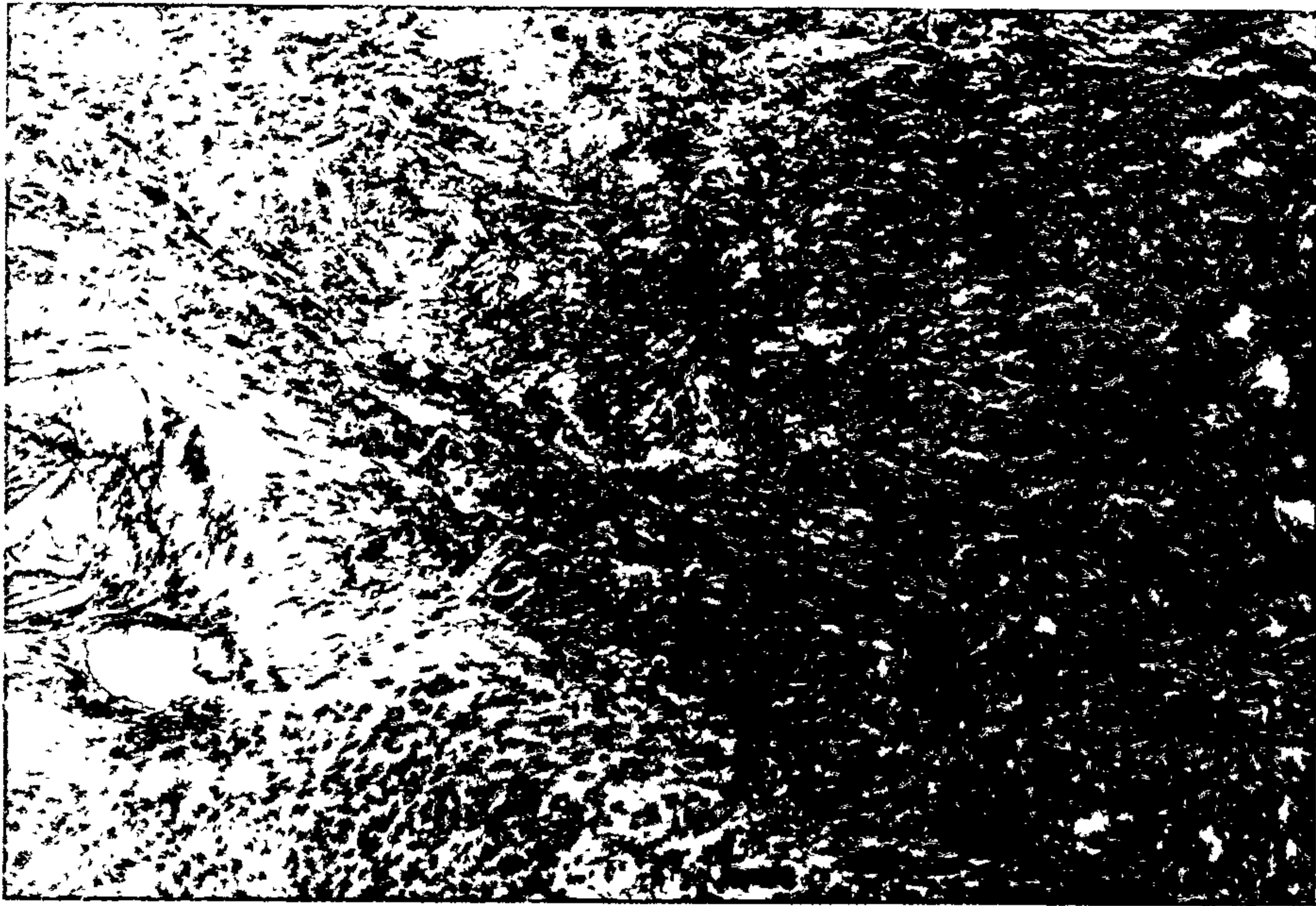
This is an area of the buccal papilla of the same specimen as seen in Figures 6 to 8. Collagen bundles travelling in the occlusal plane interweave in the form of a plexus : some bundles rise vertically at A into this plexus. Two purple stained, oval shaped oxytalan fibres, indicated by arrows, rise between and at right angles to those collagen bundles travelling in the occlusal plane.

Figure 11 Slide 20 (R3) x 125 LR 6-7, occlusal plane, peracetic acid, aldehyde fuchsin with Halmi counterstain.

This photomicrograph is from the same section as Figure 10. Purple oxytalan fibres are very numerous. Some travel with the collagen fibre bundles as at A, but many are seen end on as at B, passing between and at right angles to collagen fibre bundles travelling in the occlusal plane.

MESIO-DISTAL

GOL LINING



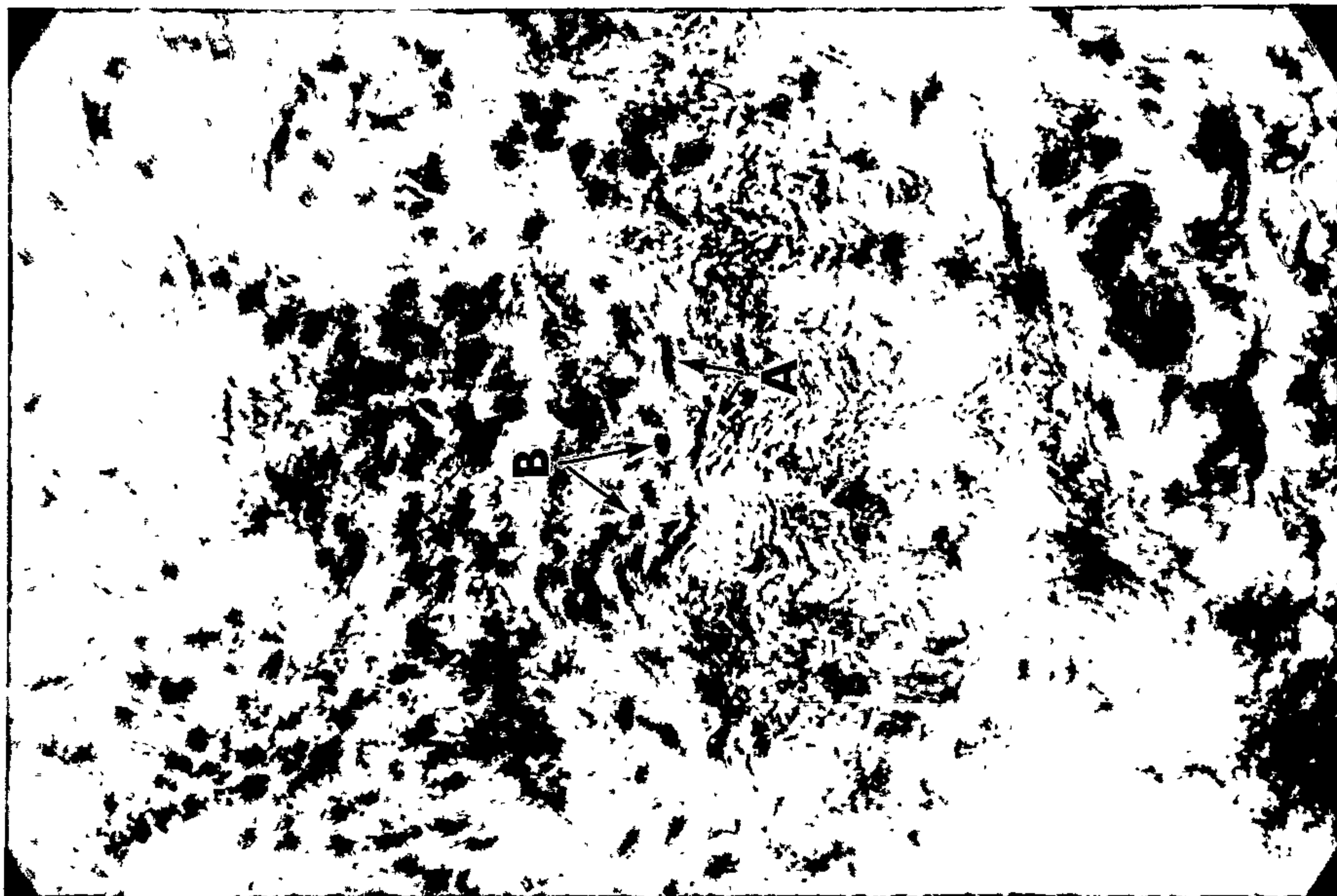
50μ

ALVEOLAR CREST

MESIO-DISTAL

BUCCO-LINGUAL

GOL LINING



20μ

ALVEOLAR CREST

BUCCO-LINGUAL

Figure 12 Slide 8 (R5) x 252 UR6-7

Buccolingual plane peracetic acid,
aldehyde fuchsin with Halmi counterstain

Oxytalan fibres are seen associated with and above
a buccolingual collagen fibre bundle in the buccal
half of the col. The oxytalan fibres run in
different directions, some being seen full length
as at A, others in cross sections as at B.

Figure 13 Slide 46 (R6) x 125 UL4-5

Aldehyde fuchsin with Halmi
counterstain, mesiodistal plane

This photomicrograph is from the middle of
a gingival papilla in which no clear
orientation of the collagen fibre bundles
were found, nor were oxytalan fibres seen.
Purple stains are mucopolysaccharide
concentrations, which may be associated
with metabolism of the collagen fibre
bundles.

Figure 14 Slide 109 (R10) x 25 U13-4

Buccolingual plane, Peracetic acid,
aldehyde fuchsin and Halmi counterstain

There is a dense collagen fibre plexus to which
the dentogingival collagen fibres appear to
contribute with buccolingual collagen.
fibre bundles radiating buccally from it.

Some fibre bundles at C seen end on over the
alveolar bone may be part of the
transseptal group.

Differential staining indicates that most
of the purple stain is due to oxytalan
fibres.

Figure 15 Slide 113 (R10) x 125

Buccolingual plane, Peracetic acid
aldehyde fuchsin and Halmi counter-
stain

This is a view of the base of the collagen
fibre plexus seen. There is a mat of
interwoven collagen fibre bundles.