Clinical Periodontology and Implant Dentistry

Fifth Edition

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Volume 1
BASIC CONCEPTS

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Preface

When the groundwork for the fifth edition of *Clinical Periodontology and Implant Dentistry* began in early 2007, it became clear that we had reached a fork in the road. It has always been my intention that each successive edition of this work should reflect the state of the art of clinical periodontology and, in doing such, should run the gamut of topics within this subject area. However, thorough coverage of an already large and now rapidly expanding specialty has resulted in a book of commensurate size and therefore for the fifth edition, the decision was taken to divide the book into two volumes: basic concepts and clinical concepts. The decision to make the split a purely physical one, and not an intellectual one, reflects the realization that over the past decade, implant dentistry has become a basic part of periodontology. The integrated structure of this latest edition of the textbook mirrors this merger.

In order for the student of dentistry, whatever his or her level, to learn how teeth and implants may function together as separate or connected units in the same dentition, a sound knowledge of the tissues that surround the natural tooth and the dental implant, as well as an understanding of the various lesions that may occur in the supporting tissues, is imperative. Hence, in both volumes of the textbook, chapters dealing with traditional periodontal issues, such as anatomy, pathology and treatment, are followed by similar topics related to tissues surrounding dental implants. In the first volume of the fifth edition, "basic concepts" as they relate to anatomy, microbiology and pathology, for example, are presented, while in the second volume ("clinical concepts"), various aspects of often evidence-based periodontal and restorative examination and treatment procedures are outlined.

It is my hope that the fifth edition of *Clinical Periodontology and Implant Dentistry* will challenge the reader intellectually, provide elucidation and clarity of information, and also impart an understanding of how the information presented in the text can, and should, be used in the practice of contemporary dentistry.

Jan Lindhe

Part 1: Anatomy

Chapter 1

The Anatomy of Periodontal Tissues

Jan Lindhe, Thorkild Karring, and Maurício Araújo

Introduction

This chapter includes a brief description of the characteristics of the normal periodontium. It is assumed that the reader has prior knowledge of oral embryology and histology. The periodontium (peri = around, odontos = tooth) comprises the following tissues (Fig. 1-1): (1) the *gingiva* (G), (2) the *periodontal ligament* (PL), (3) the *root cementum* (RC), and (4) the *alveolar bone* (AP). The alveolar bone consists of two components, the *alveolar bone proper* (ABP) and the alveolar process. The alveolar bone proper, also called "bundle bone", is continuous with the alveolar process and forms the thin bone plate that lines the alveolus of the tooth.

The main function of the periodontium is to attach the tooth to the bone tissue of the jaws and to maintain the integrity of the surface of the masticatory mucosa of the oral cavity. The periodontium, also called "the attachment apparatus" or "the supporting tissues of the teeth", constitutes a developmental, biologic, and functional unit which undergoes certain changes with age and is, in addition, subjected to morphologic changes related to functional alterations and alterations in the oral environment.

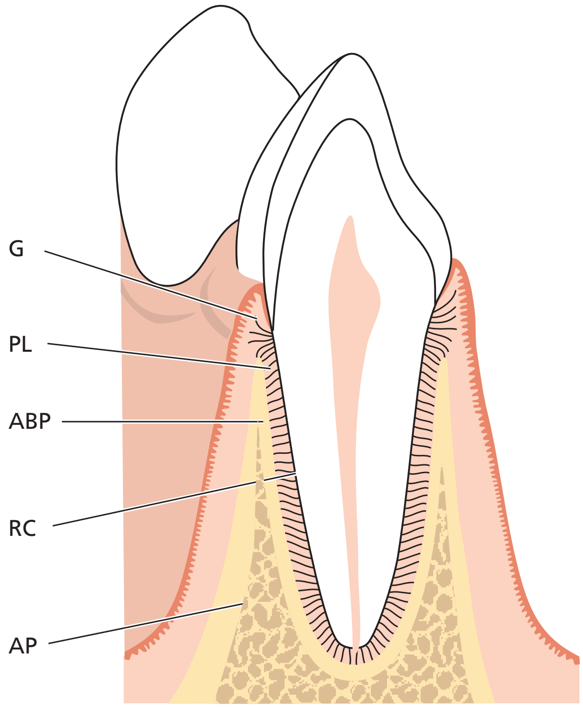

Fig. 1-1

The development of the periodontal tissues occurs during the development and formation of teeth. This process starts early in the embryonic phase when cells from the neural crest (from the neural tube of the embryo) migrate into the first branchial arch. In this position the neural crest cells form a band of *ectomesenchyme* beneath the epithelium of the stomatodeum (the primitive oral cavity). After the uncommitted neural crest cells have reached their location in the jaw space, the epithelium of the stomatodeum releases factors which initiate epithelial–ectomesenchymal interactions. Once these interactions have occurred, the ectomesenchyme takes the dominant role in the further development. Following the formation of the *dental lamina*, a series of processes are initiated (bud stage, cap stage, bell stage with root development) which result in the formation of a tooth and its surrounding periodontal tissues, including the alveolar bone proper. During the cap stage, condensation of ectomesenchymal cells appears in relation to the dental epithelium (the dental organ (DO)),

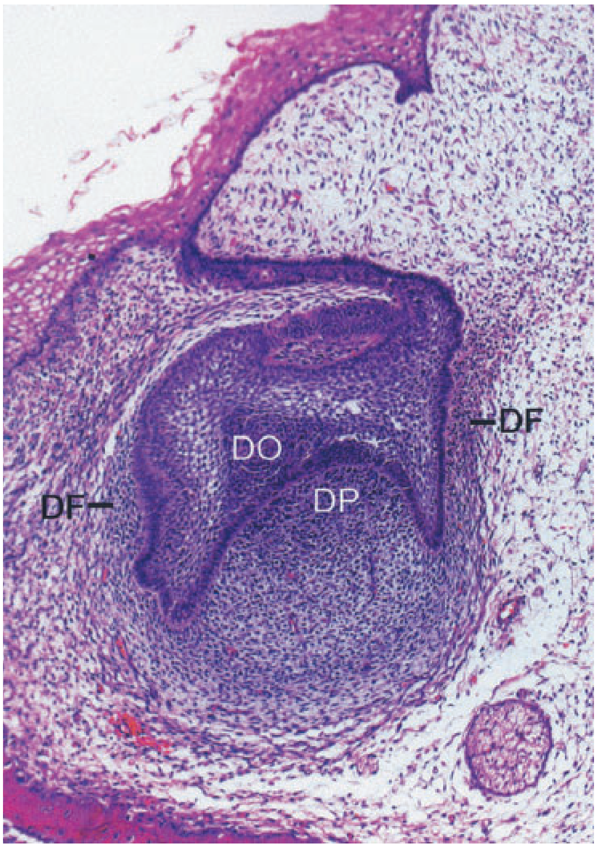

Fig. 1-2

forming the *dental papilla* (DP) that gives rise to the dentin and the pulp, and the *dental follicle* (DF) that gives rise to the periodontal supporting tissues (Fig. 1-2). The decisive role played by the ectomesenchyme in this process is further established by the fact that the tissue of the dental papilla apparently also determines the shape and form of the tooth.

If a tooth germ in the bell stage of development is dissected and transplanted to an ectopic site (e.g. the connective tissue or the anterior chamber of the eye), the tooth formation process continues. The crown and the root are formed, and the supporting structures, i.e. cementum, periodontal ligament, and a thin lamina of alveolar bone proper, also develop. Such experiments document that all information necessary for the formation of a tooth and its attachment apparatus obviously resides within the tissues of the dental organ and the surrounding ectomesenchyme. The dental organ is the formative organ of enamel, the dental papilla is the formative organ of the dentin–pulp complex, and the dental follicle is the formative organ of the attachment apparatus (the cementum, the periodontal ligament, and the alveolar bone proper).

The development of the root and the periodontal supporting tissues follows that of the crown. Epithelial cells of the external and internal dental epithelium (the dental organ) proliferate in an apical direction forming a double layer of cells named *Hertwig's epithelial root sheath* (RS). The odontoblasts (OB) forming the dentin of the root differentiate from ecto-

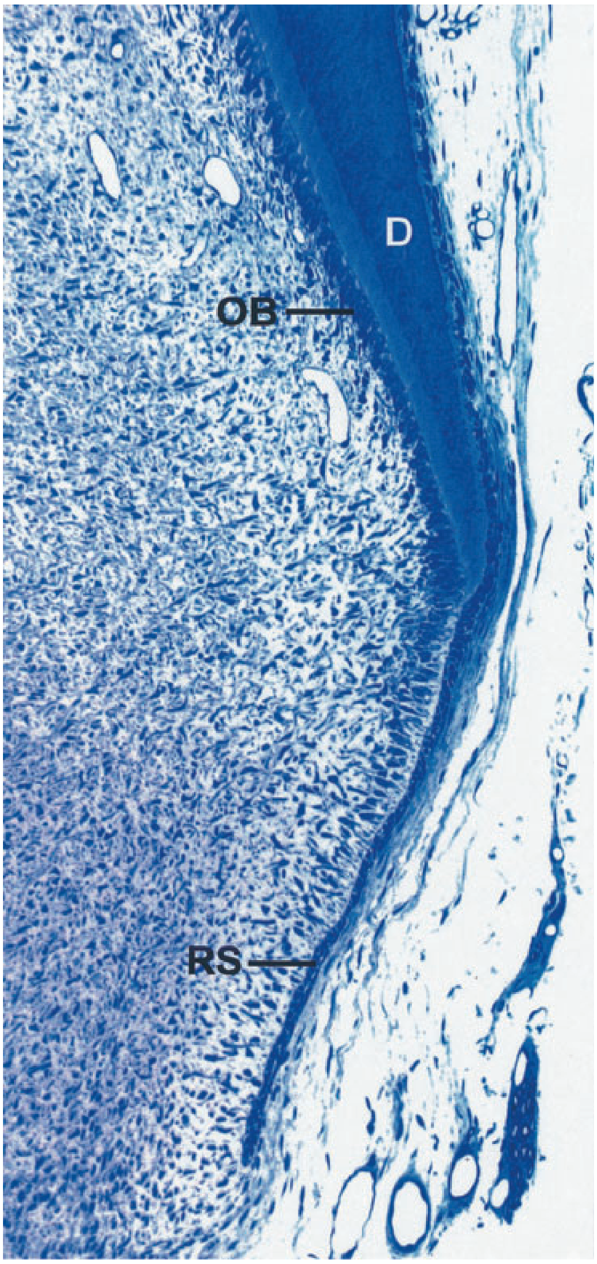

Fig. 1-3

mesenchymal cells in the dental papilla under inductive influence of the inner epithelial cells (Fig. 1-3). The dentin (D) continues to form in an apical direction producing the framework of the root. During formation of the root, the periodontal supporting tissues, including acellular cementum, develop. Some of the events in the cementogenesis are still unclear, but the following concept is gradually emerging.

At the start of dentin formation, the inner cells of Hertwig's epithelial root sheath synthesize and secrete enamel-related proteins, probably belonging to the amelogenin family. At the end of this period, the epithelial root sheath becomes fenestrated and ectomesenchymal cells from the dental follicle penetrate through these fenestrations and contact the root surface. The ectomesenchymal cells in contact with the enamel-related proteins differentiate into cementoblasts and start to form cementoid. This cementoid

Fig. 1-4

Fig. 1-5

represents the organic matrix of the cementum and consists of a ground substance and collagen fibers, which intermingle with collagen fibers in the not yet fully mineralized outer layer of the dentin. It is assumed that the cementum becomes firmly attached to the dentin through these fiber interactions. The formation of the cellular cementum, which covers the apical third of the dental roots, differs from that of acellular cementum in that some of the cementoblasts become embedded in the cementum.

The remaining parts of the periodontium are formed by ectomesenchymal cells from the dental follicle lateral to the cementum. Some of them differentiate into periodontal fibroblasts and form the fibers of the periodontal ligament while others become osteoblasts producing the alveolar bone proper in which the periodontal fibers are anchored. In other words, the primary alveolar wall is also an ectomesenchymal product. It is likely, but still not conclusively documented, that ectomesenchymal cells remain in the mature periodontium and take part in the turnover of this tissue.

Gingiva

Macroscopic anatomy

The oral mucosa (mucous membrane) is continuous with the skin of the lips and the mucosa of the soft palate and pharynx. The oral mucosa consists of (1) the *masticatory mucosa*, which includes the gingiva and the covering of the hard palate, (2) the *specialized mucosa*, which covers the dorsum of the tongue, and (3) the remaining part, called the *lining mucosa*.

Fig. 1-4 The gingiva is that part of the masticatory mucosa which covers the alveolar process and surrounds the cervical portion of the teeth. It consists of an epithelial layer and an underlying connective tissue layer called the *lamina propria*. The gingiva obtains its final shape and texture in conjunction with eruption of the teeth.

In the coronal direction the coral pink gingiva terminates in the *free gingival margin*, which has a scalloped outline. In the apical direction the gingiva is continuous with the loose, darker red *alveolar mucosa* (lining mucosa) from which the gingiva is separated by a usually easily recognizable borderline called

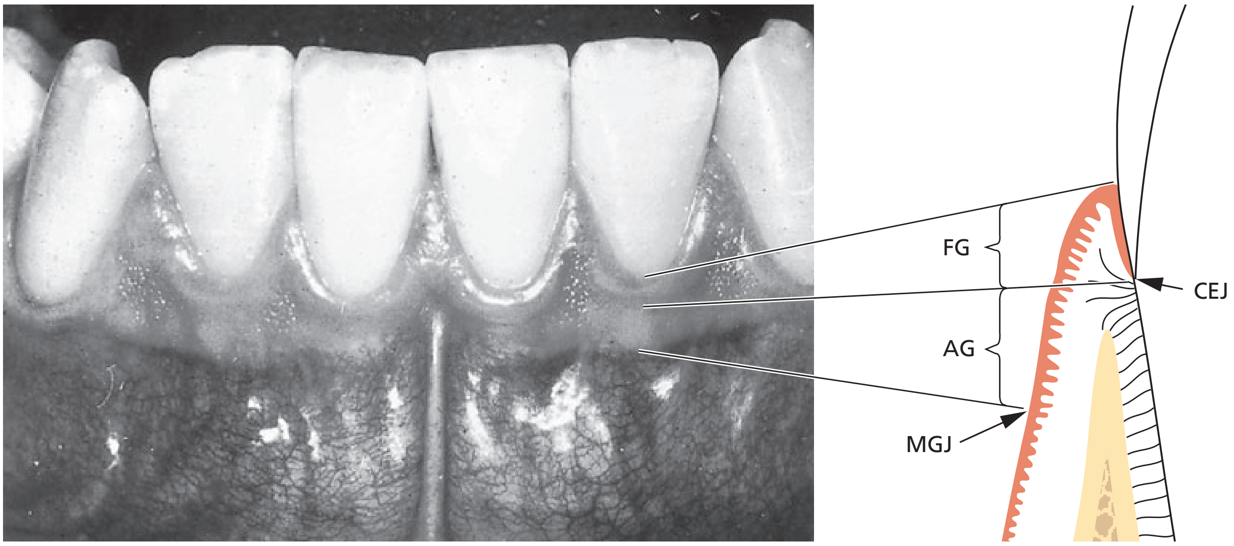

Fig. 1-6

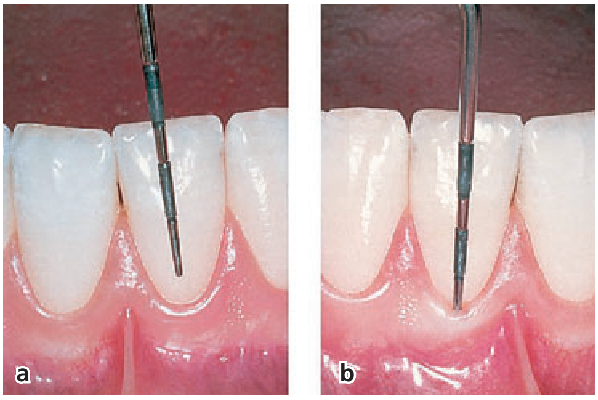

Fig. 1-7

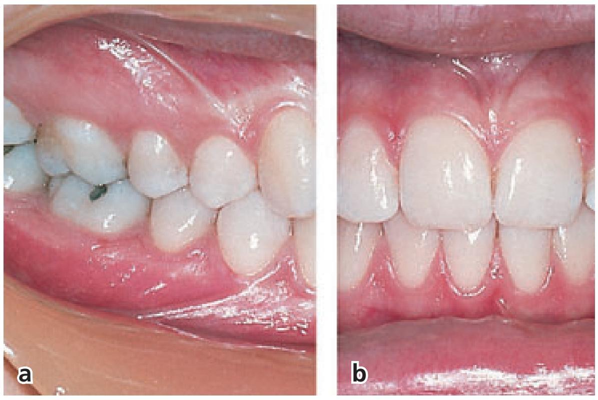

Fig. 1-8

either the mucogingival junction (arrows) or the mucogingival line.

Fig. 1-5 There is no mucogingival line present in the palate since the hard palate and the maxillary alveolar process are covered by the same type of masticatory mucosa.

Fig. 1-6 Two parts of the gingiva can be differentiated:

1. The free gingiva (FG)
2. The attached gingiva (AG).

The free gingiva is coral pink, has a dull surface and firm consistency. It comprises the gingival tissue at the vestibular and lingual/palatal aspects of the teeth, and the *interdental gingiva* or the *interdental papillae*. On the vestibular and lingual side of the teeth, the free gingiva extends from the gingival margin in apical direction to the *free gingival groove* which is positioned at a level corresponding to the level of the *cemento-enamel junction* (CEJ). The attached gingiva is demarcated by the mucogingival junction (MGJ) in the apical direction.

Fig. 1-7 The free gingival margin is often rounded in such a way that a small invagination or sulcus is formed between the tooth and the gingiva (Fig. 1-7a).

When a periodontal probe is inserted into this invagination and, further apically, towards the cemento-enamel junction, the gingival tissue is separated from the tooth, and a "*gingival pocket*" or "*gingival crevice*" is artificially opened. Thus, in normal or clinically healthy gingiva there is in fact no "gingival pocket" or "gingival crevice" present but the gingiva is in close contact with the enamel surface. In the illustration to the right (Fig. 1-7b), a periodontal probe has been inserted in the tooth/gingiva interface and a "gingival crevice" artificially opened approximately to the level of the cemento-enamel junction.

After completed tooth eruption, the free gingival margin is located on the enamel surface approximately 1.5–2 mm coronal to the cemento-enamel junction.

Fig. 1-8 The shape of the interdental gingiva (the interdental papilla) is determined by the contact relationships between the teeth, the width of the approximal tooth surfaces, and the course of the cemento-enamel junction. In anterior regions of the

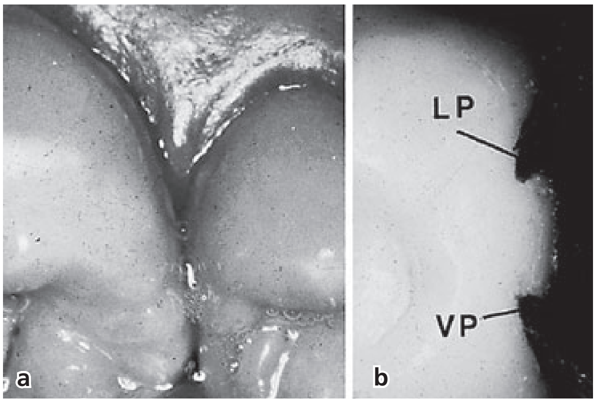

Fig. 1-9

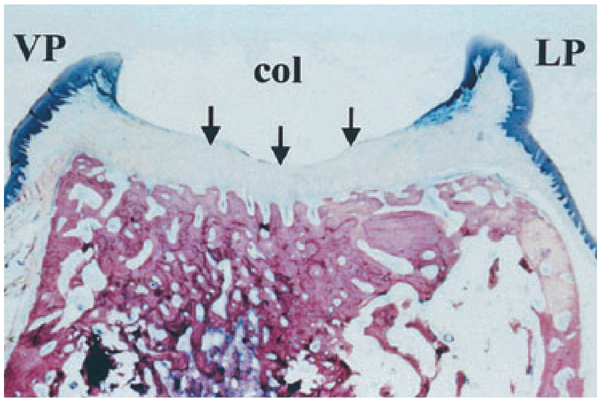

Fig. 1-9c

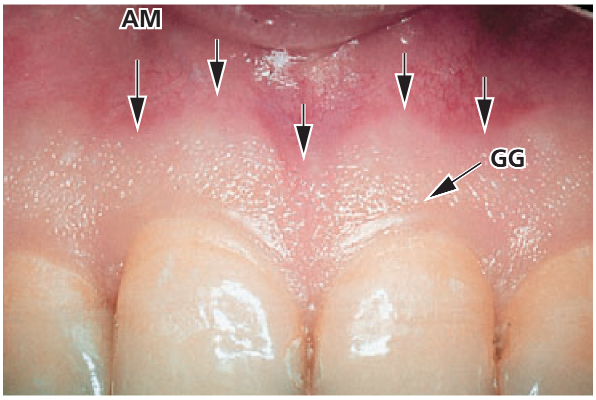

Fig. 1-10

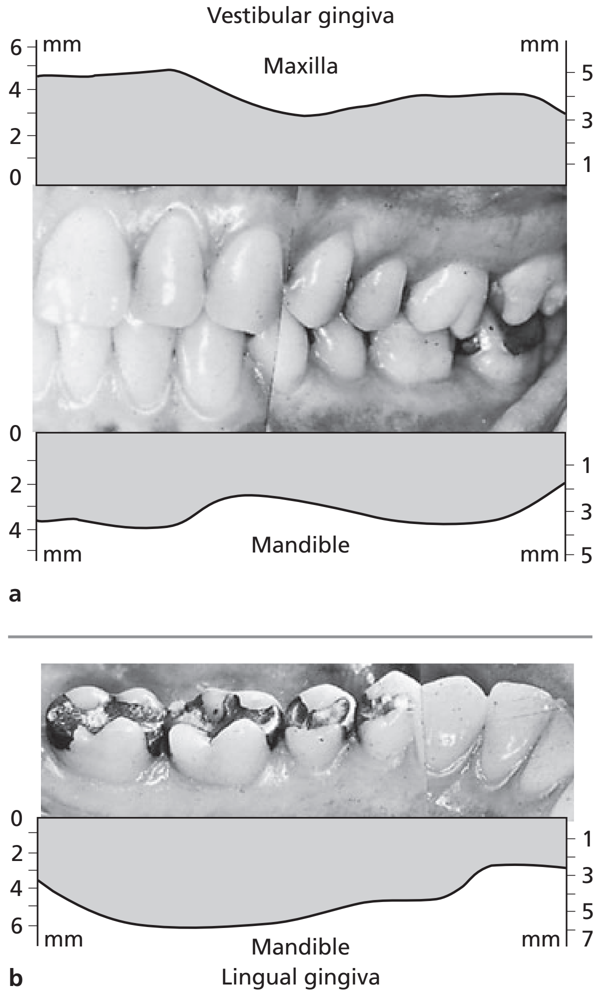

Fig. 1-11

dentition, the interdental papilla is of pyramidal form (Fig. 1-8b) while in the molar regions, the papillae are more flattened in the buccolingual direction (Fig. 1-8a). Due to the presence of interdental papillae, the free gingival margin follows a more or less accentuated, scalloped course through the dentition.

Fig. 1-9 In the premolar/molar regions of the dentition, the teeth have approximal contact surfaces (Fig. 1-9a) rather than contact points. Since the interdental papilla has a shape in conformity with the outline of the interdental contact surfaces, a concavity – *a col* – is established in the premolar and molar regions, as demonstrated in Fig. 1-9b, where the distal tooth has been removed. Thus, the interdental papillae in these areas often have one vestibular (VP) and one lingual/palatal portion (LP) separated by the col region. The col region, as demonstrated in the histological section (Fig. 1-9c), is covered by a thin non-keratinized epithelium (arrows). This epithelium has many features in common with the junctional epithelium (see Fig. 1-34).

Fig. 1-10 The attached gingiva is demarcated in the coronal direction, by the free gingival groove (GG) or, when such a groove is not present, by a horizontal plane placed at the level of the cemento-enamel junction. In clinical examinations it was observed that a free gingival groove is only present in about 30–40% of adults.

The free gingival groove is often most pronounced on the vestibular aspect of the teeth, occurring most frequently in the incisor and premolar regions of the mandible, and least frequently in the mandibular molar and maxillary premolar regions.

The attached gingiva extends in the apical direction to the mucogingival junction (arrows), where it becomes continuous with the alveolar (lining) mucosa (AM). It is of firm texture, coral pink in color, and often shows small depressions on the surface. The depressions, named “stippling”, give the appearance

Fig. 1-12

of orange peel. It is firmly attached to the underlying alveolar bone and cementum by connective tissue fibers, and is, therefore, comparatively immobile in relation to the underlying tissue. The darker red alveolar mucosa (AM) located apical to the mucogingival junction, on the other hand, is loosely bound to the underlying bone. Therefore, in contrast to the attached gingiva, the alveolar mucosa is mobile in relation to the underlying tissue.

Fig. 1-11 describes how the width of the gingiva varies in different parts of the mouth. In the maxilla (Fig. 1-11a) the vestibular gingiva is generally widest in the area of the incisors and most narrow adjacent to the premolars. In the mandible (Fig. 1-11b) the gingiva on the lingual aspect is particularly narrow in the area of the incisors and wide in the molar region. The range of variation is 1–9 mm.

Fig. 1-12 illustrates an area in the mandibular premolar region where the gingiva is extremely narrow. The arrows indicate the location of the mucogingival junction. The mucosa has been stained with an iodine solution in order to distinguish more accurately between the gingiva and the alveolar mucosa.

Fig. 1-13 depicts the result of a study in which the width of the attached gingiva was assessed and related to the age of the patients examined. It was found that the gingiva in 40–50-year-olds was significantly wider than that in 20–30-year-olds. This observation indicates that the width of the gingiva tends to increase with age. Since the mucogingival junction remains stable throughout life in relation to the lower border of the mandible, the increasing width of the gingiva may suggest that the teeth, as a result of occlusal wear, erupt slowly throughout life.

Microscopic anatomy

Oral epithelium

Fig. 1-14a A schematic drawing of a histologic section (see Fig. 1-14b) describing the composition of the gingiva and the contact area between the gingiva and the enamel (E).

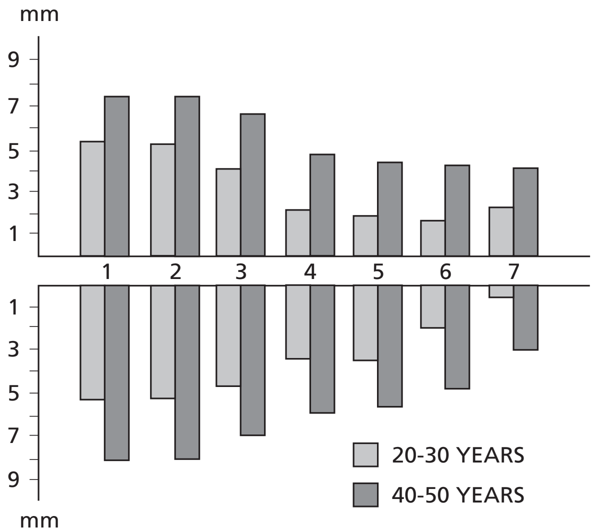

Fig. 1-13

Fig 1-14b The free gingiva comprises all epithelial and connective tissue structures (CT) located coronal to a horizontal line placed at the level of the cemento-enamel junction (CEJ). The epithelium covering the free gingiva may be differentiated as follows:

- *Oral epithelium* (OE), which faces the oral cavity
- *Oral sulcular epithelium* (OSE), which faces the tooth without being in contact with the tooth surface
- *Junctional epithelium* (JE), which provides the contact between the gingiva and the tooth.

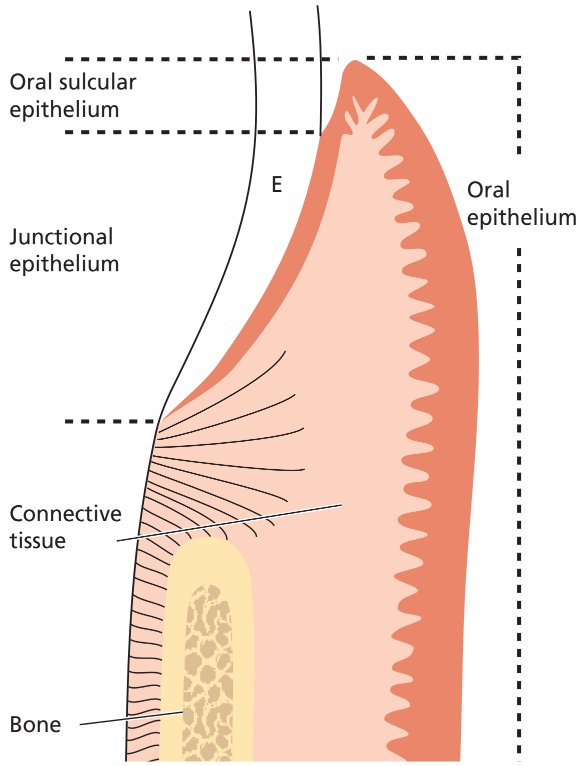

Fig. 1-14a