Structure and function of the human periodontium

Science meets the clinician

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Link to publication

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Citation for published version (APA):
Chapter 1

General introduction
Introduction

Periodontology is the fundament of all dental disciplines and a stable fundament is needed for a stable construction. A healthy periodontium is a prerequisite to achieve optimal results of any kind of dental treatment such as prosthodontics or orthodontics. However, periodontology is not yet an open book for the clinician and scientific input is still needed to further stabilize the fundamentals of dental disciplines. Fruitful cooperation between clinician and scientist and an intensive collaboration are key to increase our understanding of oral biology and its diseases and to implement novel protocols for diagnosis, prognosis and treatment to achieve successful and long lasting clinical results. Fruitful cooperation between clinician and scientist needs overlap of their knowledge and expertise so that they understand each other sides of the story, the successes but also the failures of periodontal treatment on the one hand and on the other hand understanding or lack of understanding of relevant periodontal structures and functions down to molecular interactions. These aspects are essential for so-called translational research that is most proliferative when multidisciplinary research groups with both clinical expertise and fundamental research expertise are sharing respectfully the hits and misses of their research. That is in my opinion, the best guarantee for breakthroughs in periodontal diagnosis, prognosis, and therapy.

These days, 3-dimensional (3D) histology is a hot topic in the scientific world. The tremendous developments in microscopy, such as confocal microscopy, light-sheet microscopy, nanoscopy, life cell and tissue imaging have enabled that. The 3D structure of the central nervous system and in particular of mouse brain and also mouse embryos are now successfully studied in many research groups all over the world (Azaripour et al., 2016). However, the structure of periodontal tissues has not been investigated yet using 3D histology despite the fact that a 3D histological approach of periodontium may elucidate novel functional aspects that can be affected by diseases of the periodontium. The periodontium is a specialized tissue that keeps teeth in their position. An important function is protection of the roots of teeth against external noxa. The origin of the word “periodontium” is Greek. Peri (περί) means "around" and odontos (ὀδόντος) means "tooth". So, periodontium means "around the tooth". Periodontium consists of 4 main tissue components: gingiva, periodontal ligament, cementum and alveolar bone. All 4 tissues contain large amounts of extracellular matrix (ECM). In comparison, the central nervous system and embryos contain little ECM.
Therefore, the 3D histology techniques that are presently available mainly for brain and embryos may not be suitable for periodontium.

From the clinical point of view, objective measurements of the responses of periodontal tissue to dental treatments are a key element to determine success or failure of periodontal therapy. The efficacy of novel periodontal treatment methods such as laser treatment (e.g. photodynamic therapy (PDT)), the use of herbal toothpastes or special mouthrinses for periodontal supportive therapy can be examined using these periodontal indices. Similarly, implications of modern materials for dental fillings, crowns or orthodontic aligners for periodontal tissues can be determined as well for example whether they are biocompatible or not. These indices include the amount of plaque around teeth, the bleeding behavior of gingiva and the depth of periodontal pockets. The success of a periodontal therapy can be objectivated by these indices. However, not only clinical examinations but also histological examinations are needed to analyse the effects of therapy on periodontium at the tissue and cellular level. Traditionally, histological examination has been performed in 2D. The application of 3D histology may open a new venue to acquire novel information on periodontal tissue functioning in health and disease.

The first aim of the present research project was to develop an application of 3D histology on ECM-rich tissues such as gingiva. Especially 3D reconstructions of blood vessel networks in gingiva were a major goal of this application to investigate changes in the architecture of the gingival blood vessel network in diseases such as diabetes or in patients with strong smoking habits.

The second aim of the present research project was the evaluation of responses of periodontal tissues in different (clinical) conditions. Since PDT is a novel and promising technique to support periodontal therapy, we decided to perform a systematic review and meta-analysis to evaluate its clinical effectiveness. Furthermore, only limited studies have investigated toxicity of PDT in human periodontal tissues. Therefore, an in-vitro study investigating the biocompatibility of PDT was performed using gingival fibroblasts and osteoblasts.

Prevention of oral inflammation is considered to be a key element of good oral and systemic health (Lancet, 2009). Herbal toothpastes are increasingly frequent in the spot lights as promising dentifrices. Miswak is an old dental tool (chewing stick) from trees of the family
Salvadoraceae (Salvadora persica) and it has been used for centuries in ancient cultures like that of Persians. Parodontax® is also a herbal toothpaste which is available since many years and its effectiveness has been confirmed in various studies. The third aim of the present research project was the evaluation of the effectiveness of a Miswak extract-containing toothpaste in comparison to Parodontax® and a well-documented and effective conventional toothpaste (Colgate®) in a prospective randomized clinical trial.

Tools and chemical compounds in addition to mechanical plaque control may be helpful to support oral health (Löe and Schiott, 1970; Paraskevas and van der Weijden, 2006). Additional chemical plaque control as part of domestic oral hygiene has always been playing an important role in the treatment of gingival inflammation. Aluminium triformate (ATF), an aluminium salt, has been used for several decades to control gingival inflammation and is considered to be safe for daily use. We performed a clinical short-term pilot study to address the fourth aim of the recent research project by analyzing the effects of ATF as active component in a double blind randomized placebo-controlled clinical trial.

Invisalign® is a rather novel orthodontic appliance that has been considered to be an alternative for fixed orthodontic appliances (FOA) since 1999 (Azaripour et al., 2015). In comparison to FOA, Invisalign® rarely disturbs the appearance of a patient and oral hygiene measures may be implemented more easily since Invisalign® is a removable dental aligner. However, an objective comparative study of FOA and Invisalign® has not been performed thus far. The fifth aim of the present research project was a clinical cross sectional study of the advantages and disadvantages of FOA and Invisalign® for periodontium.

In the general discussion and summary, the findings of our studies are discussed with respect to periodontal health and suggestions for further research are made to improve diagnosis, prognosis and treatment in diseased conditions of the periodontium.
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References


