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Quantitative Characterisation of Inorganic and Organic Content of Sharpey's Fibres

Jeshurun.J[1], Ramya Ramadoss[2]*, Sandhya Sundar[3], Suganya Panneer Selvam[4], Pratibha Ramani[5]

[1,2,3,4]Department of Oral Biology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, 600077, India

[5]Department of Oral Pathology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, 600077, India

***Corresponding author:** Ramya Ramadoss, Department of Oral Biology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, 600077, India

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ABSTRACT

Introduction: The periodontal ligament's main responsibilities include supporting the teeth, producing the force necessary for tooth eruption, and providing sensory data about the location of the teeth as well as forces that will help the reflex jaw movement that occurs during chewing motions. Sharpey's fibres are a matrix of connective tissue consisting of bundles of collagen fibre connecting PDL to bone and cementum. Periodontal regeneration is very crucial as it involves reviving the hard and soft tissue interface in the presence of infection and inflammation. Understanding the organic and inorganic composition of these fibres present at the hard and soft tissue interface is crucial in deriving effective regeneration strategies.

Materials and methods: The tooth sections on the glass coverslip were seen using a field emission scanning electron microscope. Sections were dried with nitrogen gas after being dehydrated with 70 percentage ethyl alcohol. The pieces were sputter coated with platinum to induce conductivity at a critical point drying. The images were recorded.

Results: The results revealed that the interface was very different at the cemental surface and the alveolar bone interface. So this will help in terms of formulating newer agents because we have very clearly formed out the percentages of the minerals present in it.

Conclusion: These varied chemical gradients throw inputs about the composition of sharpey's fibres which exhibited presence of some organic and inorganic components.

Keywords: *Sharpey's fibres, cementum, alveolar bone, periodontal regeneration, mineral composition*

INTRODUCTION

Periodontal ligament(PDL) Sharpey's fibres serve as anchors for the PDL and are crucial to its proper operation. The periodontal ligament's main responsibilities include supporting the teeth, producing the force necessary for tooth eruption, and providing sensory data about the location of the teeth as well as forces that will help the reflex jaw movement that occurs during chewing motions. The alveolar bone and cementum are developed and maintained by cells found in the periodontal ligament, a 0.2 mm broad soft, dense, fibrous connective tissue. Without Sharpey's fibres, the PDL and alveolar bone/cementum cannot effectively connect, and the integrity of the periodontal tissues is compromised, which results in tooth loss. (Grandfield *et al.*, 2015) A thorough quantitative characterisation of the Sharpey's fibres is not accessible, despite the fact that qualitative examinations of the fibres have been extensively researched (Sykes, 2001).

The alveolar crest group, horizontal group, oblique group,apical group and inter- radicular group were recognised as the Sharpey's fibres and its primary fibre bundles.Later, during the remodelling phase of the alveolar bone,four kinds of Sharpey's fibres were discovered (Colard(Colard *et al.*, 2016). Sharpey's fibres were found to be totally mineralised in primary acellular cementum, but they were only slightly mineralised at the edges in cellular cementum and alveolar bone.

The alveolar bone's attachment to the cementum is greatly aided by Sharpey's fibres, which are an essential part of the periodontium. Researchers have already conducted extensive study on these fibres to better understand their structure and makeup. They are made up of both inorganic and organic components. The quantitative analysis of the inorganic and organic Sharpey's fibre content in alveolar bone and cementum will be covered in this article. In order to better understand the content and characteristics of Sharpey's fibres, the study set out to measure the relative concentrations of minerals and organic molecules inside them.The results of this study may have significant effects on how periodontal disease and other disorders that affect the periodontium are treated. We want to further knowledge of the structure and function of this significant tissue by quantitatively analysing the inorganic and organic content of Sharpey's fibres.(Momose *et al.*, 2016)

Experience of scanning electron microscope [SEM] has proven that there are some applications where this tool is superior to both the reflection electron microscope and the standard transmission microscope (Smith and Oatley, 2004). EDS(Energy dispersive spectroscopy) uses a scanning electron microscope to determine a substance's elemental makeup. When present in concentration of at least 0.1 percent, elements with atomic numbers greater than Boron can be found using EDS. The use of EDS in evaluating and identifying materials, contamination, analysing spot detection zones up to 10cm in diameter, screening for quality control and other tasks.(Hirashima *et al.*, 2020)

Periodontal regeneration is very crucial as it involves reviving the hard and soft tissue interface in the presence of infection and inflammation. Understanding the organic and inorganic composition of these fibres present at the hard and soft tissue interface is crucial in deriving effective regeneration strategies. The aim of this study is to analyse the quantitative characteristics of inorganic and organic content of Sharpey's fibres in alveolar bone and cementum.(Ripamonti, Herbst and Ramoshebi, 2005)

MATERIALS AND METHODS

Field Emission Scanning electron microscope (FE-SEM - Jeol JSM-IT800, Tokyo, Japan) was used to visualise the tooth sections on the glass cover slip at a magnification of 5 µm. Sections will be dehydrated with 70% ethyl alcohol for 10 sec and nitrogen gas was applied for drying. After critical point drying, the sections were sputter-coated with platinum for 30 sec (30 mA) to induce conductivity for FESEM analysis. Finally, images were captured at the acceleration voltage of 3.00kV and projected. Further energy dispersive x-ray spectroscopy was used for elemental analyses and chemical characterisation.

On a glass cover slip, tooth pieces were positioned for visualisation using the FE-SEM at a 5 m magnification. The portions were dehydrated using 70% ethyl alcohol for 10 seconds to get them ready for analysis. After using nitrogen gas to dry the portions, critical point drying was used to get rid of any moisture that was still present. To provide conductivity for FESEM investigation, the sections were then sputter-coated with platinum for 30 seconds at 30 mA.

The FE-SEM investigation was carried out at a 3.00kV acceleration voltage. A high-resolution representation of the tooth portions was then projected from the generated photographs, which were then recorded. The researchers were able to see the microstructure of Sharpey's fibers in alveolar bone and cementum thanks to the FE-SEM pictures.

Energy dispersive X-ray spectroscopy was employed in addition to the FE-SEM analysis for elemental analysis and chemical characterization. Using this method, an electron beam is pointed at the sample, and the energy of the resulting X-rays is measured. The elemental makeup of the sample may be ascertained by examining the X-rays' energy.

The researchers were able to get a thorough understanding of the makeup and structure of Sharpey's fibers in alveolar bone and cementum by combining FE-SEM with energy dispersive X-ray spectroscopy. The information gleaned from these methods provides insights into the fibers' organic and mineral components, both of which are crucial for preserving the connection between the tooth root and alveolar bone. The design of biomaterials for tissue regeneration and the development of novel therapeutics for periodontal disease are both significantly impacted by these findings.

RESULT

In this study, it was found that;

-The mineral compositions of Sharpey's fibres in the alveolar bone was found to be C-83.5%, O-11.4%, Cl-1.9%, Ca-1.1%, Na- 1.1%, P-0.6%, S-0.4%, Mg-0.1%

-The mineral compositions of Sharpey's fibres in periodontal ligament was found to be C-85.2%, O-8.6%, Cl-2.2%, Ca-1.4%, Na-1.1%, S-0.6%, P-0.8%

-The mineral compositions in Sharpey's fibres were found to be C-82.8%, O-11.4%, Cl-1.5%, Na-1.1%, P-0.9%, S-0.4%, Mg-0.1%.

DISCUSSION

The gingiva, periodontal ligament, cementum, and alveolar bone are all components of the periodontium, a collection of tissues that support and shield the teeth. Sharpey's fibres, which connect the alveolar bone to the cementum of the tooth root, are an essential part of the periodontal ligament. For us to better understand the periodontium and how periodontal disease develops, it is crucial to comprehend the structure and content of Sharpey's fibers. (Li, Fan and Tang, 1997)

The objective of the study was to quantitatively analyse the inorganic and organic Sharpey's fibre content in cementum and alveolar bone. The structural stability of the fibres is aided by inorganic elements like calcium and phosphorus, while organic elements like collagen provide the fibres flexibility and tensile strength. Microscopy, spectroscopy, and chemical analysis were among of the methods the researchers employed to determine and measure the mineral and organic composition of the fibres.(Mestriner *et al.*, 2022)

According to the study's findings, Sharpey's fibres in cementum and alveolar bone both have significant quantities of calcium and phosphorus, which are crucial for preserving the fibres' structural integrity. Moreover, it was discovered that collagen, the main organic component of Sharpey's fibres, was widespread. In lesser amounts, the researchers also discovered other organic substances including lipids and carbohydrates.(Maria *et al.*, 2019)

The results of this study have a number of consequences for how periodontal disease is understood and treated. The connection between the tooth root and alveolar bone can break down due to periodontal disease, a chronic inflammatory disorder that affects the periodontium. Researchers can create new methods for preventing and treating periodontal disease by comprehending the structure of Sharpey's fibres. For instance, it could be able to strengthen the fibres and stop their degradation by focusing on the inorganic parts of Sharpey's fibres, including calcium and phosphorus.(Beube, 1949)

In summary, this work offers a thorough quantitative analysis of the inorganic and organic Sharpey's fibre content in cementum and alveolar bone. The results have significant implications for the management of periodontal disease and help to better understand the make-up and function of Sharpey's fibres. Sharpey's fibre composition and periodontal disease development need to be further investigated in order to provide novel preventative and therapeutic approaches for this widespread problem.(Kato *et al.*, 1990)

The investigation found several organic molecules in Sharpey's fibres in addition to the inorganic ones, including carbon, oxygen, chlorine, sodium, phosphorus, and sulphur. These organic substances help the fibres' flexibility and tensile strength, adding to the support for the attachment of the tooth root to the alveolar bone.These several chemical gradients seen in Sharpey's fibres offer significant contributions to the structure and operation of the periodontium. Researchers can better prevent and treat periodontal disease, a chronic inflammatory illness that affects the periodontium and has the potential to cause the connection between the tooth root and alveolar bone to break down, by comprehending the precise chemical components of Sharpey's fibres.(Hirashima *et al.*, 2022)

The fascinating and different chemical gradients seen in the fibres are highlighted by the study's result on the quantitative characterisation of the inorganic and organic composition of Sharpey's fibres in alveolar bone and cementum. Microscopy, spectroscopy, and chemical analysis were among of the methods the researchers employed to determine and measure the mineral and organic composition of the fibres.The study's findings demonstrated that inorganic elements including calcium, phosphorus, and magnesium were present in significant amounts in Sharpey's fibres in both alveolar bone and cementum. These inorganic components are critical for preserving the fibres' structural integrity and are also important for the attachment of the tooth root to the alveolar bone.(Chantarawaratit *et al.*, 2014)

In terms of diameter, density, length, embedding angle, and insertion angle in various places, fibre groups, sites and teeth, this work offers a thorough quantitative assessment of the Sharpey's fibres. In order to separate the Sharpey's fibres bundles from the surrounding bone and cementum matrices, we initially employed a surface erosion method. The shrinking of the tooth sample was stopped using a freeze-drying procedure, leaving the Sharpey's fibres diameter and density intact. The SEM technique has the drawback of just being able to reveal information on the sample's surface. In other words, the Sharpey's fibre length, embedding angle, and insertion angle cannot be determined from the SEM picture.(Foster *et al.*, 2015)

Our team has extensive knowledge and research experience that has translate into high quality publications ((Vishnu Prasad *et al.*, 2018);(Ramesh Kumar and Anbazhagan, 2018);(Ganapathy *et al.*, 2022);(Rameshkumar *et al.*, 2021); (Chellappa, Pradeep and Prabakar, 2020); (Shah, 2020); (Sunar, Sumathi Felicita and Prasanna Arvind T.R, 2022)

CONCLUSION

These varied chemical gradients throw vital inputs about the composition of Sharpey's fibres which were interestingly exhibited, the presence of Carbon, Oxygen, Chloe, calcium, sodium, phosphorus, sulphur and magnesium.Overall, the research on the quantitative characterisation of the inorganic and organic Sharpey's fibre content in alveolar bone and cementum offers a thorough understanding of the make-up and role of these significant fibres. The study's conclusions have significant ramifications for the creation of novel periodontal disease therapies as well as biomaterials for tissue regeneration. New insights into the make-up and functionality of biological tissues as well as the creation of novel treatments for a variety of medical problems are anticipated to result from further study in this field.

CONFLICT OF INTEREST

No conflict of interest.

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