PDL Oxytalan Fibres, Microvasculature
and
Clinical Orthodontics

Milton Reginald Sims, AO, BDS, MScD, PhD, FRACDS, FICD

A series of publications submitted for the degree of
Doctor of Dental Science

Adelaide, South Australia
July 15th, 2003
TABLE OF CONTENTS

SIGNLED STATEMENT vi
ACKNOWLEDGEMENTS vii
PREFACE viii

SECTION I. HUMAN AND RODENT OXYTALAN FIBRE MESHWORKS
OVERVIEW:


SECTION II. PDL MICROVASCULATURE AND FUNCTION
OVERVIEW:


SECTION III. MICROVASCULAR BED IMMUNOLABELLING

OVERVIEW:


SECTION IV. CLINICAL PUBLICATIONS

OVERVIEW:


English translation attached
Japanese translation attached


Paper 38  Sims MR. 1992. La technique de Begg et le milieu facial. (Begg technique and the facial milieu.) L'Orthodontie Française 65:777-792.


APPENDIX 1. Co-authored publications arising from personally designed and directed postgraduate MDS research projects

Papers 1.1-1.26

APPENDIX 2. Listing and published abstracts of research presentations at national and international conferences

Abstracts 1.1-1.38

APPENDIX 3. CD-ROM: Movies of ET-1 and α-SMA immunolabelling

Movies 1-15
PREFACE

For a clinician, the orthodontic relocation of teeth poses an ongoing challenge to achieve a better understanding of the processes involved in the rapid reconstitution of the periodontal tissues. Every long-term research venture has its inspirations. In this endeavour, it was Dr Kaare Reitan who lectured to us as postgraduate students at St. Louis University. Also my Boston University research classmate, Dr Harold J Hayes, tragically killed soon after graduating, who shared with me the excitement of our joint investigations of tooth movement in dogs.

In this thesis, studies of the PDL-oxytalan fibre meshwork and microvascular blood vessel system comprise the first three biological sections. Evidence is provided for the reconstitution of the human oxytalan fibre system and statistical data support the hypothesis that collagen and oxytalan fibres perform different dynamic functions. Tooth ankylosis confirms the maintenance of the oxytalan fibre cementum-vascular meshwork, while ultrastructural studies reveal the oxytalan fibre relationships to the peripheral neural system and the blood vessel wall. Statistical data show species differences in oxytalan microfibrillar structures. These additional findings provide further support for the author's original PhD hypotheses which remain extant.

The intimate associations existing between the oxytalan fibre system and PDL microvasculature have led the author to study this peripheral vascular bed. Blood vessels play a pivotal role in the maintenance and function of tissue. Nevertheless, knowledge of PDL vessel geometry and wall ultrastructure has long been limited.

The physiologically active postcapillary-sized venule segment is shown to contain ~60% of the blood volume. Most of these venule profiles present as endothelial tubes with pericyte cells. Stereologically, aged PDL microvasculature is proved to undergo major changes in anatomy, distribution and physiological function.

Normally, the PDL vasculature is subjected to intermittent masticatory loads or, at the other extreme, orthodontically superimposed continuous loads in excess of 18 months duration. The latter loads can result in the ~350μm wide ligament being reconstituted through the bone at ~60μm/day over distances of 7-8mm. Thus, the vessel endothelium, pericytes and arterioles smooth muscle must undergo a rapid and continuous processes of remodelling, including both shutdown and proliferation.

Early responses of vascular endothelial cells to continuous tooth loading for periods from 1 to 3 hours have been evaluated using immunolabelling in rodents and non-human primates. Significant region by treatment interactions occur for endothelin-1 labelling in both vascular endothelium and bone surface cells. Furthermore, it is demonstrated that upregulation of both ET-1 and α-SMA occurs in the PDL vessels of non-human primates after 1½ hours. Clearly, immunolabelling offers a valuable technique to examine early PDL vascular cell responses to tooth loading.

Section IV comprises a series of clinical publications. These papers were requested principally from the author's clinical orthodontic courses and lectures. The material includes descriptions of the theory and application of the Begg orthodontic technique. Other subjects cover diagnosis, anchorage control and conservation, bite opening, incisor torque, finishing and concepts of facial aesthetics. The final paper in this group suggests some possible avenues of future orthodontic development.

These personal investigations resulted in the design, supervision and publication of a series of postgraduate research studies directed primarily to the microvasculature.