



THE EFFECTS OF COMPRESSIVE FORCES ON CELLS *IN VITRO*  
A HISTOCHEMICAL AND AUTORADIOGRAPHIC STUDY

by  
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TABLE OF CONTENTS

	Page
TITLE	
ACKNOWLEDGEMENTS	i
TABLE OF CONTENTS	iii
SUMMARY	vii
DECLARATION	x
 CHAPTER I	
INTRODUCTION	1
1. The Problem	1
2. Review of the Literature on the Effects of Stress on Tissues	5
A. In Biological Systems	5
B. In Medicine	18
(i) Mechanical Stresses	18
(ii) Effects of Electric Currents and the Piezoelectric Phenomenon	28
C. In the Orthodontic Field	36
(i) Histological Findings	36
(a) Orthodontic Techniques and Methods of Applying Forces to Teeth	42
(b) Observations on Bodily Tooth Movement and Tipping Tooth Movement	47
(c) The Influence of Function on Orthodontic Tooth Movement	48
(d) Age and Sex Factors Relating to Tooth Movement	50
(e) Special Effects of Rotational Forces	52
(f) The Effect of Extrusion and Intrusion Forces	53
(g) Changes following Reversed Tooth Movement	56

	Page
(h) Tooth Movement into Alveolar Sockets following Extraction	57
(i) Hormonal Influences on Tooth Movement	58
(ii) Application of some Recent Techniques to the Problems of Orthodontic Tooth Movement	59
(a) Autoradiography	59
(b) Histochemistry	64
(c) Tetracycline Tracing	66
(d) Electric Phenomena	67
(e) Electron Microscopy	68
(f) Biochemical Investigations	69
(g) Physiological Investigations	70
(iii) Attempts to Elucidate the Biological Basis of Tooth Movement	74
D. Summary of Literature Survey	78
3. The use of Cell Culture Techniques	80
CHAPTER II MATERIALS AND METHODS	83
1. Cell Culture System	83
2. Application of Compressive Forces	85
3. Cytochemistry	88
Haematoxylin	89
Feulgen reaction	89
Periodic acid-Schiff (PAS) reaction	90
Sudan black B	91
Aldehyde fuchsin-alcian blue	91
Alkaline phosphatase	92

	Page
Acid phosphatase	93
Succinic dehydrogenase	93
Cytochrome oxidase	94
Diphosphopyridine nucleotide (DPN)- linked dehydrogenases	95
Glutamic acid dehydrogenase	95
Malic dehydrogenase	95
$\alpha$ -glycerophosphate dehydrogenase	95
Lactic dehydrogenase	95
4. Autoradiography	96
 CHAPTER III	
RESULTS	100
1. Cytochemistry	100
Haematoxylin	100
Feulgen reaction	101
Periodic acid-Schiff (PAS) reaction	102
Aldehyde fuchsin - alcian blue	102
Sudan black B	102
Alkaline phosphatase	103
Acid phosphatase	103
Succinic dehydrogenase	104
Cytochrome oxidase	105
Diphosphopyridine nucleotide (DPN)- linked dehydrogenases	106
Glutamic acid dehydrogenase	106
Malic dehydrogenase	106
$\alpha$ -glycerophosphate dehydrogenase	106
lactic dehydrogenase	106
2. Autoradiography	107
$H^3$ -thymidine	108
$H^3$ -uridine	109
$H^3$ -proline	109

	Page	
CHAPTER IV	DISCUSSION OF PRESENT RESULTS	110
	1. Cytochemistry	110
	2. Autoradiography	119
	3. Rationalization of present findings	122
CHAPTER V	GENERAL DISCUSSION	127
	A. On The Effects of Mechanical Stress on Cells	127
	B. On the Mechanism of Orthodontic Tooth Movement	130
	C. On the Magnitude of Orthodontic Force	142
	D. On Orthodontic Tooth Movement	144
CHAPTER VI	CONCLUSIONS	146
APPENDIX		152
FIGURES		156
BIBLIOGRAPHY		161

## SUMMARY

Many workers have shown that orthodontic tooth movement is a result of bone remodelling effected by mechanical stress, which is the basis of orthodontic practice. Mechanical stresses act on various forms of both terrestrial and aquatic life. For this reason much time has been spent in a literature review of the biological and medical fields discussing the compatibility between mechanical stress and life, and in the orthodontic field spotlighting various aspects of orthodontic tooth movement related to the effects of forces on alveola tissue components.

In order to better understand the mechanisms of orthodontic tooth movement, experiments were undertaken utilizing isolated cells in tissue cultures to which known forces were applied.

Compressive forces ranging from  $10 \text{ gm/cm}^2$  to  $80 \text{ gm/cm}^2$ , which were provided by a specially fabricated apparatus, were directly applied to mouse fibroblast L-929 cells for periods ranging from 30 minutes to 4 hours.

The effects of the compressive forces on the cells were investigated with various cytochemical methods and with the use of tritiated nucleic acid and protein precursor autoradiography. As a result, cytoplasmic blister formation was observed following compression of cells with  $10 \text{ gm/cm}^2$  for 30 minutes, increasing in



proportion with the magnitude of the forces and time. Succinic dehydrogenase and cytochrome oxidase activities were severely reduced by increasing compressive forces and time and acid phosphatase activity was reduced progressively with forces of 60 and 80 gm/cm<sup>2</sup> as the duration of compression increased. However, the Feulgen reaction, periodic acid-Schiff reaction, Sudan black B, glutamic, malic,  $\alpha$ -glycerophosphate - and lactic dehydrogenases were not visibly affected under the experimental conditions.

Incorporation of H<sup>3</sup>-thymidine, H<sup>3</sup>-uridine and H<sup>3</sup>-proline was not affected except for a slight decrease following the longest experimental period.

The results are discussed with respect to the biological relations of the techniques employed. It is considered that disturbance of even one cellular function could result in malfunction of other cell components leading to cell death. On these grounds it is concluded that any force applied for a long enough time could overstress cells in the strictest sense. However, if compressive forces must be used to accomplish a certain goal, possible tissue damages could be minimized by the use of optimal forces. Such considerations may have quite practical applications to orthodontics.

Finally, the present results are related to bone resorption and the mechanism of orthodontic tooth movement. Either direct or secondary effects of compressive forces may play an important role

in stimulating either the already existing cells capable of bone resorption, or precursor cells, to differentiate into mature osteoclastic cells. An attempt is made to explain the mechanism by a negative feedback system whose ultimate goal is to retain homeostasis. Before a completely satisfactory mechanism can be proposed, it is emphasized that more information on the milieu of bone resorption, particularly the micro-environment of osteoclasts, is required.

## DECLARATION

I declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any University, and to the best of my knowledge contains no material previously published by another person, except where due reference is made in the text.

The results have been presented in part to a meeting of the Australian Society of Orthodontists, 1972. Some of the material is in preparation for submission to scientific journals for publication.

MASAAKI NAKAMURA

Date

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