THE EFFECTS OF COMPRESSIVE FORCES ON CELLS *IN VITRO*

A HISTOCHEMICAL AND AUTORADIOGRAPHIC STUDY

by

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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 gm/cm^2 to 80 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 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^2 as the duration of compression increased. However, the Feulgen reaction, periodic acid-Schiff reaction, Sudan black B, glutamic, malic, α-glycerophosphate - and lactic dehydrogenases were not visibly affected under the experimental conditions.

Incorporation of H^3-thymidine, H^3-uridine and H^3-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.

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