INVESTIGATION OF VERTICAL MANDIBULAR DISTRACTION OSTEOGENESIS ON THE MASTICATORY MUSCLES IN A 'UNILATERAL HEMIFACIAL MICROSOMIA LIKE' DEFECT IN THE SHEEP MODEL

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This thesis is dedicated to my wife Halilah Wan Muhammad and our four children Alya Fatini, Asna Qistina, Ahnaf Imran and Aniq Hafiy. Not forgotten to my father Haji Shaari Haji Abdullah, my late mother Allahyarhamah Hajjah Halimah Ahmad, My in laws Haji Wan Muhammad Wan Jaffar and Hajjah Wan Hasnah Wan Yussof.

STATEMENT

This study is part of a much larger study into distraction osteogenesis in the sheep model, which is being directed by Professor Alastair Goss. Various defined aspects of the study have involved other postgraduate students.

Specifically they are:

All of the animal surgery was performed jointly by myself and Dr Sharifah A.J. Syed Zainal. Her thesis specifically focuses on the bone aspect of this research project. As alteration in the soft tissue directly relates to changes in the bone, I have acknowledged her study in the body of this thesis.

Dr Con Vanco, in association with Dr. Sharifah, performed the initial pilot study. He looked at the bone morphogenic protein by using immunohistochemistry techniques. Dr Neena Durairaj, studied the histology of the condyle and the regenerated condyle from the condylectomy.

Both Dr. Sharifah A.J. Syed Zainal and Dr. Con Vanco have received the Doctorate of Clinical Dentistry (Oral Maxillofacial Surgery and Orthodontics and Dr. Neena Durairaj is in the process of getting her Honours Degree.

Unless otherwise stated as above, and acknowledged in the body of the thesis, this work is original and contains no material which has been accepted for the award of any other degree or diploma in any University or any other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where the due reference has been made in the text.

I give consent for this copy of my thesis, when deposited in the University library, to be available for loan and photocopying.

Signed_____

Rumaizi Shaari

Date: _____

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ABSTRACT

Distraction osteogenesis is a recently developed option for surgical correction of the craniofacial discrepancy but there are few studies that look at the long-term effect of the relapse phenomenon. This study was conducted to look at the bone and muscle response at different consolidation and remodelling periods.

Thirty ten-week-old Merino lambs were subjected to this current study. The surgically created defect was performed on the experimental side (right) by superficial masseter myectomy and a condylectomy. The lambs showed a midline shift to the affected side three months later. Marker screws were placed on both sides of the mandible to examine the adjustment of the vertical and horizontal dimension of the mandible. In this present study, the left side was used as the control.

The affected mandible was surgically corrected using a vertical ramus distraction osteogenesis protocol. The latency period was 7 days where the device was inactive. Distraction was then performed at 1 mm per day until the distracted gap was 10 mm on a radiograph. Initially, the sheep were divided into 8 groups but later the groups were refined into 6 groups for statistical analysis;

Group 1: Immediately post distraction

Group 2: Consolidation 2 months and remodelling 1 month

Group 3: Consolidation 3 months

Group 4: Consolidation 3 months and remodelling 1 month

Group 5: Consolidation 3 months and remodelling 2 months

Group 6: Consolidation 4 months

A ‘hemifacial microsomia like’ defect was successfully created and it was then corrected using vertical ramus distraction. Cephalometric examination showed that the vertical height was significantly increased after the distraction was completed.

Examination of the bone and muscle was performed to look at the adjustment of bone structure in relation to relapse. The bone investigation was conducted using radiological analysis, histological analysis and direct measurement of the vertical screws at pre-distraction and at sacrifice as well as histomorphometric analysis. The radiological examination was conducted using cephalometric analysis of the distance between marker screws on both experimental and control sides. Bone histology was investigated on the middle and posterior position of the experimental side. The histomorphometric analysis was conducted using Quantiment analysis software.

The muscle responses and adaptation were investigated by measuring: the weight of the masseter and medial pterygoid muscles; length between 6 different points (4 landmarks); cross section and thickness of masseter muscles by ultrasound and by histopathological examination of both masseter and medial pterygoid muscles on the experimental and the control sides.

The distracted bone showed a completion of maturation after a three month consolidation period. Bone formation was shown to continue after longer consolidation periods. A two-month consolidation period was insufficient time for the bone to consolidate and stable, as there was evidenced of relapse during this period.

There was no increased in muscle mass after distraction. The distraction altered the length of anterior and posterior planes and the size of cross sectional area and thickness of origin and middle level of masseter muscles. There were no changes in the length of the middle and oblique planes and the cross sectional area of the insertion of the masseter muscle. The distracted muscle adapted well after a longer consolidation and remodelling period but was sensitive to any surgical procedure such as device removal. The adjustment was observed to continue within the first month after surgical removal of device. The weight, length of planes, cross section and thickness was temporarily reduced on the experimental side but continued to improve and stabled during the second month after removal of the device. The first month after device removal also showed that histopathological activity was increased after both 2 and 3 month consolidation periods. Importantly, muscle histopathology was back to almost normal activity after the second month of device removal, following a 3 month consolidation period.

This study showed that it was possible to create a 'hemifacial microsomia like' defect in very young lambs. The defect was then successfully corrected by a vertical distraction osteogenesis procedure. It was also shown that the sufficient time for the device to be fixed in place (consolidation period) was 3 months or longer as the bone and muscle was stable after that period of time. Results from this investigation have important implications to the management of similar conditions in humans.

PUBLICATIONS ARISING FROM THIS THESIS

ABSTRACTS

1. Shaari, R, Syed Zainal, S, Kuchel ,T and Goss, AN.

   The effect of vertical mandibular distraction osteogenesis on masticatory muscles in sheep model. CACDRC (Colgate Australian Clinical Dental Research Centre Research Day): 22 August 2003. Adelaide, South Australia.

2. Shaari, R, Syed Zainal, S, Kuchel ,T and Goss, AN,

   The effect of distraction on the masticatory muscles. 20th Biennial Conference ANZAOMS (Australian and New Zealand Association of Oral and Maxillofacial Surgeons). 3-6 September 2003. Adelaide, South Australia.

3. Shaari, R, Syed Zainal, S, Kuchel ,T and Goss, AN.

   The effect of vertical mandibular distraction osteogenesis on masticatory muscles in sheep model. IADR (International Australian Dental Research). 29 September 2003. Melbourne, Victoria.

ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variances
ºC	Degree Celsius
C.T	Computerised tomography
CCD	Change-coupled device
gm	Gram
mg	Milligram
kg	Kilogram
µm	Micrometre
mm	Millimetre
cm	centimetre
mm^2	Millimetre Square
ml	Millilitre
H & E	Haematoxylin and eosin
Hfm	Hemifacial microsomia strain mouse
HFM	Hemifacial microsomia
MHz	Mega Hz
pH	Negative logarithm of H^+ concentration expressed in molarity
RHBS	Residual bone host segments
PCNA	Proliferating cell nuclear antigen
RNA	Ribonucleic acid
DNA	Deoxyribonucleic acid
OMENS	Orbital dystropia, Mandibular hypoplasia, Ear (external), Nerve (Cranial) and Soft tissue discrepancy
SAT	Skeletal-auricular and soft tissue

TMJ	Temporomandibular joint
kV	Kilovolt
mAS	milliampere per second
RC	Repeatability Coefficient
ºA	Angström unit
3D	Three dimensions
%	Percentage
↑	Increase
↓	Decrease
↔	Remain the same