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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Thesis submitted for the degree of
DOCTOR OF PHILOSOPHY (PhD)

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October, 2005
Revision September, 2008
4.6.3 Consolidation for 2 months (Group 2a) 121
4.6.4 Consolidation 2 months and remodelling 1 month (Group 2) 121
4.6.5 Consolidation 3 months (Group 3) 122
4.6.6 Consolidation 3 months and remodelling 1 month (Group 4) 122
4.6.7 Consolidation 3 months and remodelling 2 month (Group 5) 122
4.6.8 Consolidation 4 months (Group 6) 123

4.7 Bone Structure 123

4.8 Gross Masticatory Muscle Changes 124

4.8.1 Weight of masticatory muscles 124
  4.8.1.1 Weight of masseter muscles 124
  4.8.1.2 Weight of Medial Pterygoid Muscle 128

4.8.2 Length of Four Planes on Masseter Muscles. 131
  4.8.2.1 Length of Anterior Plane of Masseter Muscle (AB) 132
  4.8.2.2 Length of middle plane of masseter muscle (CD) 134
  4.8.2.3 Length of Posterior Plane of Masseter Muscle (EF) 137
  4.8.2.4 Length of Oblique plane of Masseter Muscle (AD) 140

4.8.3 Ultrasonography 144

4.8.3.1 Cross Section (mm²) of Masseter Muscle 144
  4.8.3.1.1 Cross Section (mm²) of proximal Masseter Muscle 145
  4.8.3.1.2 Cross Section (mm²) of Middle Masseter Muscle 149
  4.8.3.1.3 Cross Section (mm²) of Distal Masseter Muscle 152

4.8.3.2 Thickness (mm) of Masseter Muscle 156
  4.8.3.2.1 Thickness (mm) of Proximal Masseter Muscle 157
  4.8.3.2.2 Thickness (mm) of Middle Masseter Muscle 159
  4.8.3.2.3 Thickness (mm) of Distal Masseter Muscle 162

4.9 Histopathology Quantitative Score 165
  4.9.1 Immediately post distraction (Group 1) 167
  4.9.2 Consolidation 2 months and remodelling 1 month (Group 2) 167
  4.9.3 Consolidation 3 months (Group 3) 168
  4.9.4 Consolidation 3 months and remodelling 1 month (Group 4) 168
  4.9.5 Consolidation 3 months and remodelling 2 months (Group 5) 169
  4.9.6 Consolidation 4 months (Group 6) 169

4.10 Other Findings 184
  4.10.1 Sarcocystis Species 184
  4.10.2 Prevalence of Sarcocystis species infection in sheep 186

CHAPTER 5: DISCUSSION 187

5.1 Selection of Sheep as Animal Model 187

5.2 Mortality and Morbidity 188
5.3 Mandibular Growth 190

5.4 Issues relating to the model 191
  5.4.1 Biomechanics of masticatory forces, effect on position and fixation 191
  5.4.2 Device design and stability 192

5.5 Vertical Mandibular Distraction Osteogenesis on ‘Unilateral Hemifacial Microsomia Like’ Defect. 193

5.6 Repeatability Coefficient 194

5.7 Distracted bone 195
  5.7.1 Direct measurement 195
  5.7.2 Radiological measurement 195
  5.7.3 Bone histology 196

5.8 Effect of Mandibular Distraction Osteogenesis on Masticatory Muscles in sheep limb muscle distraction. 198
  5.8.1 Weight of Masticatory Muscle 198
    5.8.1.1 Weight of Masseter Muscle 198
    5.8.1.2 Weight of Medial Pterygoid Muscle 200
  5.8.2 Length of Landmarks of Masseter Muscles 201
    5.8.2.1 Length of Anterior Plane of Masseter Muscle (AB) 201
    5.8.2.2 Length of Middle Plane of Masseter Muscle (CD) 202
    5.8.2.3 Length of Posterior Plane of Masseter Muscle (EF) 203
    5.8.2.4 Length of Oblique Plane of Masseter Muscle (AD) 203
  5.8.3 Ultrasonography 204
    5.8.3.1 Cross Section (mm²) of Masseter Muscle 204
      5.8.3.1.1 Cross Section (mm²) at the Proximal of the Masseter Muscle 204
      5.8.3.1.2 Cross Section (mm²) of Middle Masseter Muscle 205
      5.8.3.1.3 Cross Section (mm²) of Distal Masseter Muscle 206
    5.8.3.2 Thickness (mm) of Masseter Muscle 207
      5.8.3.2.1 Thickness (mm) of Proximal of Masseter Muscle 207
      5.8.3.2.2 Thickness of Middle of Masseter Muscle 207
      5.8.3.2.3 Thickness (mm) of Distal of Masseter muscle 207
  5.9 Histopathological Evaluation 208
    5.9.1 Immediately post distraction 208
    5.9.2 Consolidation 2 months and remodelling 1 month 209
    5.9.3 Consolidation 3 months 210
    5.9.4 Consolidation 3 months and remodelling 1 month 210
    5.9.5 Consolidation 3 months and remodelling 2 months 211
    5.9.6 Consolidation 4 months 211

5.10 Comparison of the findings of this study to the literature 212
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>CONCLUSIONS AND FUTURE DIRECTIONS</td>
<td>216</td>
</tr>
<tr>
<td>6.1</td>
<td>Conclusions</td>
<td>216</td>
</tr>
<tr>
<td></td>
<td>General Objectives</td>
<td>216</td>
</tr>
<tr>
<td></td>
<td>Specific Objectives</td>
<td>219</td>
</tr>
<tr>
<td>6.2</td>
<td>Future Directions</td>
<td>222</td>
</tr>
<tr>
<td>7</td>
<td>REFERENCES</td>
<td>226</td>
</tr>
<tr>
<td>8</td>
<td>APPENDIXES</td>
<td>241</td>
</tr>
</tbody>
</table>
List of Tables

Table 2.1: The stages of distraction osteogenesis, osteotomy, latency, distraction, consolidation and remodelling. 10

Table 2.2: External ear classification system by Meurman and Marx. 58

Table 2.3: Classification of hemifacial microsomia Pruzansky for Type I, II and III Kaban for Type II A and B. 59

Table 3.1: Animal for pilot study, number of sheep per group (n) and the description of the groups. 85

Table 3.2: Definition of the score for histopathological changes in masseter and medial pterygoid muscles. 97

Table 4.1: Number of sheep with problems; general health and technical problems. 111

Table 4.2: The distraction gaps in the different groups. 117

Table 4.3: The vertical distance of AB changes at post distraction (Post-D) and sacrifice (Sac). Percentage (%) of the increase (↑); decrease (↓) and remain the same (↔). 118

Table 4.4: Estimated reduction of the masseter muscle by superficial masseter myectomy. 124

Table 4.5: Paired t-test for weight of masseter muscle between control and experimental sides for six groups. 125

Table 4.6: The net change in weight (gm) of masseter muscles between the control and experimental sides in six groups. 127

Table 4.7: Paired t-test for weight of medial pterygoid muscle between control and experimental sides in six groups. 128

Table 4.8: The net change in weight (gm) of medial pterygoid muscles between the control and experimental sides in six groups. 129

Table 4.9: Repeatability coefficient for four planes and groups. 131

Table 4.10: Paired t-test for length AB (mm) (anterior plane) between control and experimental sides in six groups. 132

Table 4.11: The net change in length of anterior plane (AB) (mm) of masseter muscle between the control and experiment sides in six groups. 133

Table 4.12: Paired t-test for length CD (mm) (middle plane) between control and experimental sides in six groups. 135
Table 4.13: The net change in length of middle plane (CD) (mm) of masseter muscles between the control and experimental sides in six groups.

Table 4.14: Paired t-test for length EF (mm) (posterior plane) between control and experimental sides in six groups.

Table 4.15: The net change in length of posterior plane (EF) (mm) of masseter muscles between the control and experimental sides in six groups.

Table 4.16: Paired t-test for length AD (mm) (oblique plane) between control and experimental sides in six groups.

Table 4.17: The net change in length of oblique plane (AD) (mm) of masseter muscles between the control and experimental sides in six groups.

Table 4.18: Repeatability coefficient for cross section (mm²) of image scans at three masseter levels for control and experimental sides in six groups.

Table 4.19: Paired t-test for the cross sectional area (mm²) of scanned images of the proximal masseter muscles between control and experimental sides in six groups.

Table 4.20: The net change in cross section (mm²) of the scan images from proximal masseter muscle between the control and experimental sides in six groups.

Table 4.21: Paired t-test for the cross sectional area (mm²) of scanned images of the middle masseter muscle between control and experimental sides in six groups.

Table 4.22: The net change in cross section (mm²) of the scan images from the middle masseter muscles between the control and experimental sides in six groups.

Table 4.23: Paired t-test for cross sectional area (mm²) of scanned images at distal masseter muscles between control and experimental sides in six groups.

Table 4.24: The net change in cross section (mm²) of the scan images from the distal masseter muscles between the control and experimental sides in six groups.

Table 4.25: Repeatability coefficient for thickness (mm) of scan images at three levels of masseter muscle for control and experimental sides in six groups.

Table 4.26: Paired t-test for thickness (mm) of scan images at the proximal level of masseter muscles between control and experimental sides in six groups.

Table 4.27: The net change in thickness (mm) of the scan images from the proximal masseter muscles between the control and experimental sides in six groups.

Table 4.28: Paired t-test for thickness (mm) of scan images for middle masseter muscles between control and experimental sides in six groups.

Table 4.29: The net change in thickness (mm) of the scan images from the middle masseter muscles between the control and experimental sides in six groups.
Table 4.30: Paired t-test for thickness (mm) of scan images for distal masseter muscles between control and experimental sides in six groups.

Table 4.31: The net change in thickness (mm) of the scan images from the distal masseter muscles between the control and experimental sides in six groups.

Table 4.32: Double determination for the histological scoring.

Table 4.33: Histopathological scores for Group 1, sacrifice immediately post distraction.

Table 4.34: Histopathological scores for Group 2, consolidation 2 months and remodelling 1 month.

Table 4.35: Histopathological scores for Group 3, consolidation period for 3 months.

Table 4.36: Histopathological scores for Group 4, consolidation period for 3 months and remodelling 1 month.

Table 4.37: Histopathological scores for Group 5, consolidation period 3 months and remodelling 2 months.

Table 4.38: Histopathological scores for Group 6, consolidation period 4 months.
LIST OF GRAPHS

Graph 4. 1: The weight gain of sheep (kg) of sheep at different stages throughout experimental period. 112

Graph 4. 2: The weight (gm) of masseter muscles of the experimental and control sides in six groups. 126

Graph 4. 3: The net change in weight (gm) of masseter muscles between the control and experimental sides in six groups. 127

Graph 4. 4: The weight (gm) of medial pterygoid muscles of the experimental and control sides in six groups. 129

Graph 4. 5: The net change in weight (gm) of medial pterygoid muscles between the control and experimental sides in six groups. 130

Graph 4. 6: The length of anterior plane (AB) (mm) of masseter muscles for the experimental and control sides in six groups. 133

Graph 4. 7: The net change in length of anterior plane (AB) (mm) of masseter muscle between the control and experimental sides in six groups. 134

Graph 4. 8: The length of middle plane (CD) (mm) of masseter muscle for the experimental and control sides in six groups. 135

Graph 4. 9: The net change in length of middle plane (CD) (mm) of masseter muscles between the control and experimental sides in six groups. 136

Graph 4. 10: The length of posterior plane (EF) (mm) of masseter muscles for the experimental and control sides in six groups. 138

Graph 4. 11: The net change in length of posterior plane (EF) (mm) of masseter muscles between the control and experimental sides in six groups. 140

Graph 4. 12: The length of oblique plane (AD) (mm) of masseter muscles for the experimental and control sides in six groups. 141

Graph 4. 13: The net change in length of oblique plane (AD) (mm) of masseter muscles between the control and experimental sides in six groups. 142

Graph 4. 14: The cross section (mm²) of the scan images from the proximal masseter muscles on the experimental and control sides in six groups. 146

Graph 4. 15: The net change in cross section (mm²) of the scan images from proximal masseter muscle between the control and experimental sides in six groups. 147

Graph 4. 16: The cross section (mm²) of the scan images of the middle masseter muscles on the experimental and control sides in six groups. 150
Graph 4. 17: The net change in cross section (mm²) of the scan images from the middle masseter muscles between the control and experimental sides in six groups.

Graph 4. 18: The cross section (mm²) of the scan images from the distal masseter muscles on the experimental and control sides in six groups.

Graph 4. 19: The net change in cross section (mm²) of the scan images from the distal masseter muscles between the control and experimental sides in six groups.

Graph 4. 20: The thickness (mm) of the scanned images from the proximal masseter muscles on experimental and control sides in six groups.

Graph 4. 21: The net change in thickness (mm) of the scan images from the proximal masseter muscles between the control and experimental sides in six groups.

Graph 4. 22: The thickness (mm) of the scan images from the middle masseter muscle on the experimental and control sides in six groups.

Graph 4. 23: The net change in thickness (mm) of the scan images from the middle masseter muscles between the control and experimental sides in six groups.

Graph 4. 24: The thickness (mm) of the scan images from the distal masseter muscles on the experimental and control sides in six groups.

Graph 4. 25: The net change in the thickness (mm) of the scan images from the distal masseter muscles between the control and experimental sides in six groups.

Graph 4. 26: Histopathological activity at the proximal, middle and distal levels of the masseter muscles on the experimental side in six groups.

Graph 4. 27: Histopathological activity at proximal, middle and distal levels of the medial pterygoid muscles on the experimental side in six groups.
List of Figures

Figure 2.1: The combination of external frame and plaster casting for limbs lengthening, design by Codivilla.

Figure 2.2: The external ring to perform lower limbs lengthening, design by Ilizarov. One pair of crossed un-tensioned wires (A), one pair of crossed tensioned wires (B) and two pairs of crossed tensioned wires (C).

Figure 2.3: Radiograph (left) and schematic drawing (right) of a goat tibia demonstrating five zonal structures of distraction regeneration. FZ: fibrous interzone (radiolucent), MZ: mineralization zones (radiodense), RZ: remodelling zone (radiolucent) and RHBS: residual bone host segments.

Figure 2.4: Radiograph (left) and schematic drawing (right) of a goat tibia demonstrating structure of distraction regenerate during the consolidation periods. Note two radiolucent zones of remodelling (RZ) adjacent to the residual host bone segment (RHBS) and divided by the mineralization zones (MZ).

Figure 2.5: Photomicrographs of goat tibial distraction regenerate demonstrating the three types of bone maturation during the consolidation period.

Figure 2.6: Angell's palatal expansion appliance on the maxillary arch.

Figure 2.7: Mandibular distraction osteogenesis (unidirectional), placement of the device to hold two fragments and arrow showing the vector of distraction.

Figure 2.8: Mandibular distraction osteogenesis with bi-directional design by Molina. Vertical vector (thin arrows) and horizontal vector (solid arrows).

Figure 2.9: Mandibular distraction osteogenesis on canine mandible, (an oblique osteotomy was performed). The masseter muscle illustrated in this figure was smaller than normal.

Figure 2.10: Mandibular distraction osteogenesis on porcine mandible. An angle osteotomy on mandible. The muscles were perpendicular to the distraction vector. The movement of the bone fragments (arrows).

Figure 2.11: A drawn illustration of the small fascicle of the myofibre and structures. Perimysium (1), endomysium (2), individual myofibre (3), elongated nuclei (4), contractive myofibres (5), small myosatellite cells (6) and capillaries (7).

Figure 2.12: Normal muscle fibres (M) and muscle spindle (S), presence of several muscle fascicules and perimysium (P) × 350; H&E.

Figure 2.13: The contractile component of the skeletal muscle (sarcomere). The micro filament known as actine (A) and myosin (M).

Figure 2.14: Mechanism of skeletal muscle adapted in distraction process. Myofibril proliferation and regeneration to bridge the damage muscle.
Figure 2.15: The traction process caused the contractile unit to increase in number as adaptation to the new length. Circle shows the new sarcomere.

Figure 2.16: Mechanism of the adaptation of skeletal muscle, which involved the connective tissues. Healing by fibrous tissues formation (sclerosis).

Figure 2.17: Degeneration of the muscle fibres and sclerosis, which appeared as light pink within muscle fibres (arrows).

Figure 2.18: Increased fibrous tissues between the perimysium (arrows) and endomysium (yellow arrow heads). (H&E; X80).

Figure 2.19: Regeneration occurred at the musculotendinous junction (arrows), tendon (T) and Muscle (M).

Figure 2.20: Unilateral hemifacial microsomia patient (above) and the same patient with the device in place on the right mandible that was treated with distraction osteogenesis.

Figure 2.21: Sagittal view of the brachial region at 4 weeks. Observe the blood vessels that arise from the heart below and passes through each branchial arch.

Figure 2.22: Development of masticatory muscles. Establishment of masseter, temporalis and medial and lateral pterygoid muscles at 10 weeks.

Figure 2.23: Facial muscles overlying skull and positioned almost at final location at 10 weeks.

Figure 2.24: Facial blood supply of internal carotid artery by the stapedial artery, which is related to the common and external carotid arteries at 7 weeks.

Figure 2.25: Hfm transgenic mouse. Small ear pinna (arrow) (A), Embryo with smaller pinna (arrow) (B), Midline shift to the right side (C), and underdevelopment of mandibular arch (D).

Figure 2.26: Right middle masseter muscle (dot arrow), which is almost parallel to the vertical outline of the mandibular ramus (solid arrow).

Figure 2.27: Right medial pterygoid muscle (dot arrow), which is positioned parallel to the vertical orientation of the mandibular ramus (solid arrow).

Figure 2.28: Graphic presentation of the stress distribution on sheep mandible when the masticatory muscle is contracted at the maximum level, focus mainly at the insertion of muscles.

Figure 2.29: The anticipated movement (arrow) of the proximal and distal fragments when the device is activated. The masseter muscle is expected to experience a direct effect from the distraction process as the outline is parallel to the distraction vector.
Figure 3.1: Preauricular skin incision to approach to the right condyle (arrow head) and submandibular incision to expose the superficial masseter muscle (small arrow) in the first surgery. 74

Figure 3.2: Exposure of the right condyle (arrow) (A) and the right condyle after removal (B). 74

Figure 3.3: The right parotid duct (arrow), which has been identified before completion of the right superficial masseter myectomy. 77

Figure 3.4: The right superficial masseter muscle (arrow) (A), the blunt dissection process to separate the superficial layer from the middle masseter (B), the right superficial masseter (arrow) after removal and exposed fascia of the middle masseter muscle. 78

Figure 3.5: The right midline shift resulted from condylectomy and superficial masseter myectomy. 79

Figure 3.6: The mandibular osteotomy and the placement of the bone-born Mathys mandibular distractor (Mathys Australia Pty. Ltd, AUS- Kensington, N.S.W). 79

Figure 3.7: The lateral cephalogram before (A) and after distraction (B). The right midline shift was corrected when 10 mm gap showed on radiograph. 83

Figure 3.8: The midline shifting toward the right side resulted from condylectomy and superficial myectomy (A), the distraction process corrected the midline (B). 84

Figure 3.9: The experimental design for the pilot study, which involved one animal each for eight groups. 86

Figure 3.10: Placement of marker screws A, B and C on the mandible. 90

Figure 3.11: The placement of transducer to scan 3 levels of the masseter muscle; proximal, middle and distal. 92

Figure 3.12: The ultrasound machine, Aloka (Echo camera), model SSD 650 cl. with transducer 7.5 MHz. 93

Figure 3.13: The six anatomical points to measure four landmarks on the masseter muscle. 94

Figure 3.14: The three levels of sampling at proximal, middle and distal levels of the masseter muscle. 97

Figure 3.15: Normal architecture of masseter muscle. Normal muscle fibres (M), perimysium (P), collagen deposition (C), artery (A) and vein (V). H&E (100x). 98

Figure 3.16: Muscle dystrophy-presence of various sizes of muscle fibres within one fascicle. Normal muscle fibres (M), atrophic muscle (m), perimysium (P) and fat tissue (F). H&E (100x) 98

Figure 3.17: Muscle atrophy (a), generalize uniform reduction in fibre size with increased endomysium (E), perimysium (P) spaces and collagen deposition (C). H&E (100x). 99
Figure 3. 18: Muscle necrosis, presence of inflammatory cells and phagocytic process. Normal muscle fibres (M), necrotic fibres (N), fat tissue (F) and regeneration (R). H&E (100x).

Figure 3. 19: Proliferation of fibroblasts (arrow) increase in number of fibroblast nuclei (fb) between connective tissues at perimysium (P) and endomysium (E). Normal muscle fibres (M). H&E (400x).

Figure 3. 20: Sclerotic muscle, increased inter fascicle space and muscle fibre with connective tissues (collagen). Normal muscle fibres (M) and perimysium (P). H&E (100x).

Figure 3. 21: Regeneration of muscle (R), presence of new muscle cells (arrow) within damaged muscles. Normal muscle fibres (M). H&E (400x).

Figure 3. 22: Lateral cephalometry using cephalostat head frame.

Figure 3. 23: The sheep positioned in cephalostat head frame (A) and the result of lateral cephalometry X-ray (B). The white tape in (A) is holding the ruler in place. The marker screws, distance and the distracted gap can be visualized on radiograph.

Figure 3. 24: The marker screws A, B and C in circles. Distances between screws AB, BC and AC were measured directly on the specimen.

Figure 3. 25: Bone blocks sectioned coronally, most anterior on the right.

Figure 3. 26: Bone specimen from an experimental side to demonstrate the distracted gap, which is the zone of interest for the histomorphometric study. Van Gieson actual size.

Figure 4. 1: The post mortem finding, the intestinal perforation at duodenum, which contaminated abdominal cavity.

Figure 4. 2: Presence of yellow necrotic tissues and pus surrounding the distracted gap at post mortem.

Figure 4. 3: Presence of whitish fibrous tissues on the right distal surface of masseter muscle. The edge of the superficial masseter stump (point of forceps).

Figure 4. 4: The scan images of the proximal masseter muscle. Control side (A) and experimental side (B).

Figure 4. 5: The scan images of the middle masseter muscles and example of tracing (white tracing). Control side (A) and experimental side (B).

Figure 4. 6: The scan images of the distal masseter muscles. Control side (A) and experimental side (B).

Figure 4. 7: Normal muscle (control side). Normal muscle fibres (M), perimysium (P), artery (A), vein (V) and collagen (C). H&E (100x).
Figure 4. 8: Normal muscle (control side). Normal muscle fibres (M), muscle spindle (S), perimysium (P), vein (V) and artery (A). H&E (100x).

Figure 4. 9: Musculotendinous junction (MTJ) normal muscle (control side). Normal muscle fibres (M), tendon (T) and perimysium (P). H&E (100x).

Figure 4. 10: Dystrophy in several muscle fascicles. Normal muscle fibres (M), dystrophic muscles (Ds), perimysium (P) and fat tissues (F). H&E (40x).

Figure 4. 11: Muscular dystrophy. Dystrophic muscle (Ds), normal muscle (M), perimysium (P) and fat tissue (F). H&E (100x).

Figure 4. 12: Generalised muscle atrophy and increase in perimysial (P) and endomysial (e) spaces. Normal muscle fibre size (M). (Group 1). H&E (100x).

Figure 4. 13: Generalised muscle atrophy (m), increased perimysial (P) and endomysial (E) spaces. Normal muscle fibres (M) and fat tissues (F). (Group 1) H&E (40x).

Figure 4. 14: Generalised muscle atrophy. Atrophic muscle (m), increased perimysial spaces. Artery (A). (Group 2). H&E (100x).

Figure 4. 15: Necrosis of muscle fibres. Necrotic muscle (N), normal muscle (M), regeneration (R) and fat tissue (F). H&E (400x).

Figure 4. 16: Necrosis of muscle fibres. Necrotic muscle (N), normal muscle (M), regeneration (R) and fat tissue (F). H&E (400x).

Figure 4. 17: Necrosis of muscle fibre (N). Normal muscle (M), musculotendinous junction (MTJ) and tendon (T). H&E (400x).

Figure 4. 18: Increased connective tissues (green) in the perimysium (P) and endomysium (E). Red striping (arrows) on the collagen. Normal muscle (M) and fat tissues (F). One step Gomori's trichrome (100x).

Figure 4. 19: Presence of the red striping amongst the collagen (green). One step Gomori's trichrome (400x).

Figure 4. 20: Increase of the connective tissues at perimysium and proliferation of fibroblasts (Fb), collagen (C), normal muscle (M) and perimysium (P). H&E (400x).

Figure 4. 21: Presence of new muscle cells within the damaged muscles. Regeneration (R), necrotic muscle (N), normal muscle (M) and fat tissues (F). H&E (250x).

Figure 4. 22: Presence of regeneration (R) within damage muscle (N). Normal muscle (M). H&E (400x).

Figure 4. 23: The cross section of the Sarcocystis sp (arrow), within the muscle fibre. Normal muscle (M), nucleus of muscle (n) and endomysium (E). H&E (400x).
Figure 4. 24: The longitudinal section of *Sarcocystis sp* (arrow) within the muscle fibre of the sheep. Normal muscle (M), nucleus of muscle (n) and endomysium (E). H&E (400x). 185

Figure 4. 25: Life cycle of the genus *Sarcocystis* 186
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: ___________________
ACKNOWLEDGEMENTS

I was greatly encouraged by my supervisors, Professor Alastair Goss and Dr. Timothy Kuchel who gave me the opportunity to conduct this study. I would like to thank both of them for their endless support, patience and guidance throughout this programme.

Acknowledgements also go to my research colleague, Dr S.A.J Syed Zainal, an Oral and Maxillofacial Surgery Registrar who always shared her experience in surgical skill and knowledge in the clinical application which was helpful to understand and relate to the study. Not forgotten was Dr. J. Varughese for sharing his knowledge and experience in the distraction osteogenesis in sheep.

Thanks are also dedicated to people who give me the knowledge and shared their experience of laboratory animal experiment and management. These include Glenda Summerside (Supervisor of laboratory animal theatre of IMVS), Brian Lewis (supervisor of laboratory animal husbandry) and other staff of Institute of Medical and Veterinary Sciences (IMVS) Veterinary Division. Special thanks also go to the Animal Ethics Committee of the IMVS for allowing me to attend some of the meetings and sessions to give me an idea of how to evaluate the animal research applications.

My thanks also go to Visiting Researcher in the Australian/Japanese Jaw Joint Project, Dr. Mikio Shimitzu for sharing his experience in animal surgery and tissue processing. I also would like to express my appreciation to Sandy Hughes for her help in coordinating the training and organisation to complete my histological experiments. I would also extend my thanks to Dr. John Finnie for assisting me with the histopathology of masticatory muscles, Dr. Richard
Logan, Oral Pathology Unit, the University of Adelaide and Mrs. Marjorie Quin, for her experience in histological technique and for helping me to improve my skill and knowledge in laboratory work.

Special thanks also to Mathys Australia and the Australian New Zealand Association of Oral & Maxillofacial Surgeons, who sponsored this research. Mr. Rocco Fazzalari and Mrs Juliet Forgan of Mathys Australia, who constantly assisted us when needed.

Special thanks also to Dr. Janet Fuss, for arranging me to attend the radiological course, sit for an examination and obtain a licence. Not forgotten thanks to Mr Steve Johnson from Radiation Protection Branch, Environment Protection Authority for giving me guidance and teaching me the way to operate the X-ray machine and processing of materials.

I would also like to thank Miss Emmae Ramsay and Kristyn Willson (statistician) from Department of Public Health, General Practice, and the University of Adelaide for assisting me in statistical analysis. Special thanks also to my friend, Dr. Mohd Fadhli Khamis for helping me with data management and some statistical analyses.

I am also would like to thank the Department of General Services of Malaysia and the Science University of Malaysian for granting me a four year scholarship to pursue my PhD programme at the University of Adelaide. A special thanks also to Alison Hambour and Juliet Hugo for their help with the English, as English is not my first language.
Special additional acknowledgements:

This thesis has received a substantial number of suggestions and recommendations from the examiners for further improvement. Both of my supervisors had reviewed the examination outcomes and contributed greatly in finalising this doctoral thesis. I would like to take this opportunity to thanks Dr. Mohd Ayub Sadiq, a lecturer at the School of Dental Sciences, USM for clarifying all issues on statistical analysis throughout this thesis. My special thanks and appreciation goes to Dr. Saidi Jaafar, lecturer at School of Dental Sciences, USM for helping me rewritten this thesis with careful consideration of all the issues indicated by the examiners. Lastly, I would like to extend my gratitude to Madam Noraini @ Norizan binti Abdul Rahman, English teacher at Kubang Kerian Secondary School who has 15 years of experience for going through the language of this thesis.
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.

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

### ABBREVIATIONS AND SYMBOLS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANOVA</td>
<td>Analysis of Variances</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
</tr>
<tr>
<td>C.T</td>
<td>Computerised tomography</td>
</tr>
<tr>
<td>CCD</td>
<td>Change-coupled device</td>
</tr>
<tr>
<td>gm</td>
<td>Gram</td>
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<tr>
<td>mg</td>
<td>Milligram</td>
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<tr>
<td>kg</td>
<td>Kilogram</td>
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<tr>
<td>µm</td>
<td>Micrometre</td>
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<tr>
<td>mm</td>
<td>Millimetre</td>
</tr>
<tr>
<td>cm</td>
<td>centimetre</td>
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<tr>
<td>mm²</td>
<td>Millimetre Square</td>
</tr>
<tr>
<td>ml</td>
<td>Millilitre</td>
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<tr>
<td>H &amp; E</td>
<td>Haematoxylin and eosin</td>
</tr>
<tr>
<td>Hfm</td>
<td>Hemifacial microsomia strain mouse</td>
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<tr>
<td>HFM</td>
<td>Hemifacial microsomia</td>
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<tr>
<td>MHz</td>
<td>Mega Hz</td>
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<tr>
<td>pH</td>
<td>Negative logarithm of H⁺ concentration expressed in molarity</td>
</tr>
<tr>
<td>RHBS</td>
<td>Residual bone host segments</td>
</tr>
<tr>
<td>PCNA</td>
<td>Proliferating cell nuclear antigen</td>
</tr>
<tr>
<td>RNA</td>
<td>Ribonucleic acid</td>
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<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid</td>
</tr>
<tr>
<td>OMENS</td>
<td>Orbital dystrophia, Mandibular hypoplasia,Ear (external),Nerve (Cranial) and Soft tissue discrepancy</td>
</tr>
<tr>
<td>SAT</td>
<td>Skeletal-auricular and soft tissue</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Definition</td>
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<tr>
<td>--------------</td>
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<tr>
<td>TMJ</td>
<td>Temporomandibular joint</td>
</tr>
<tr>
<td>kV</td>
<td>Kilovolt</td>
</tr>
<tr>
<td>mAS</td>
<td>milliampere per second</td>
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<tr>
<td>RC</td>
<td>Repeatability Coefficient</td>
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<td>3D</td>
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<td>%</td>
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<td>↑</td>
<td>Increase</td>
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<td>Decrease</td>
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<td>↔</td>
<td>Remain the same</td>
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