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The Effects of Surgically Reduced Fracture Dislocations of the Mandibular Condyle on Facial Growth in Young Macaca Rhesus Monkeys

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THE EFFECTS OF SURGICALLY REDUCED FRACTURE DISLOCATIONS OF THE MANDIBULAR CONDYLE ON FACIAL GROWTH IN YOUNG MACACA RHESUS MONKEYS.

BY

Stephen J. Atsaves B.S.,D.D.S.

A Thesis Submitted to the Faculty of the Graduate School of Loyola University in Partial Fulfillment of the Requirements for the Degree of Master of Science.

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Dedicated

To

My parents, Johm and Venus Atsaves and
my wife, Katherine Yvonne Atsaves

LIFE

Stephen J. Atsaves was born in Chicago, Illinois, March 5,1936 and he was graduated from Amundsen High School, Chicago, in June, 1954.

He attended Wright Jr. college and Loyola University, where he majored in biology and recieved the degree of Bachelor of Science in June, 1958.

He began Dental School in September, 1959, and recieved the degree of Doctor of Dental Surgery from the Chicago College of Dental Surgery, Loyola University Dental School, in June, 1963.

From July, 1963 to June, 1965 he was a graduate student in the Department of Oral Biology of Loyola University, Chicago, Ill.

In June, 1965 he began a one year Fellowship in Anesthesia at Cook County Hospital, Chicago, Ill., and then completed a two year residency in Oral Surgery at the same institution.

At present, he is associated with Dr. Mitchel V. Kaminski in the practice of Oral Surgery, in Chicago, Ill., a Clinical Instructor in the Department of Oral Surgery, Loyola University Dental School a member of the Assistant Attending Staff of St. Mary of Nazareth Hospital, and the Consulting Staff of Belmont Community Hospital.

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To Dr. Nicholas C. Choukas for giving generously of his time to assist and guide me throughout my training as an Oral Surgeon and in the preparation of this thesis.

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To Franklin Boulevard Community Hospital for providing the laboratory facilities and animals necessary for this study.

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STEPHEN J. ATSAVES

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I N T R O D U C T I O N

It is a well documented fact that condylar fractures in children may result in bony ankylosis of the temporomandibular joint. Nevertheless, the choice of the treatment for fractures involving the temporomandibular articulation has remained a matter of conjecture. The literature is replete with articles expressing philosophies of treatment, ranging from those who favor no surgical intervention, to those who propose that all fracture dislocations should be surgically reduced.

Most surgeons maintain a philosophy lying somewhere between these two extremes and base their rationale of treatment upon their own experiences and / or those of their colleagues who are also involved in the treatment of these injuries.

Although the number of deformities resulting from injuries to the temporomandibular articulation is not great, regardless of how they are treated, I am sure that this is of little consolation to those individuals who are thus afflicted. Further, the degree of deformity, which may occur, depends on the age of the patient. MacLennon (1952) stated that, "children below the age of five years would appear to be more prone to permanent growth changes following fractures of the condylar process. Such damage to the growth center is bound to diminish in direct ratio to the age of the patient over five years of age". It is for this reason, that young growing monkeys were

used in this study.

It is hoped that, aside from being a rewarding personal experience, this paper will, in some way, help contribute to a more rationale and universal approach to the treatment of injuries of the temporomandibular articulation.

REVIEW OF THE LITERATURE

Sarnat and Engel (1951) performed unilateral and bilateral condylectomies in young Macaca rhesus monkeys. They found that this produced a serious interference with the growth of the mandible. Wherever one condyle was removed, an asymmetrical deformity was produced. Removal of both condyles led to a symmetrical interference with the growth of the mandible. Mandibular function did not appear to be seriously affected.

Jarabak and Stuteville (1952) resected the condyles of a young monkey in the area of the neck of the condyle, below the attachment of the lateral pterygoid muscles. They observed no facial changes after a period of six months. An open bite had developed in the incisor region from canine to canine.

Stuteville and Jarabak (1952) also performed a unilateral resection of the condyle of a monkey, without detaching the lateral pterygoid muscle, and then immediately replaced it by means of an open reduction and fixation with a vitallium plate and screws. They found no evidence of any interference with condylar growth or any occlusal disharmony.

Sarnat (1957) repeated his earlier experiment (1951), however, he allowed the animals a longer post-operative survival period. The same results were obtained except they were more accentuated. They noted a marked asymmetry of the skull in all its aspects.

Tomek (1958) reported an experiment on a young Macaca

rhesus monkey similar to that of Sarnat (1957) and confirmed the results reported by Sarnat and Engel (1951) namely, Interference with the growth of the mandible.

Hendrix, et. al. (1959) performed unilateral fractures of the mandibular condyles of two dogs. The condyle was removed and a hole was drilled through the inferior portion of the head. A similar hole was drilled through the neck of the condyle and the fracture was then reduced and fixed with transsosseous stainless steel wire. Elastics were then applied to intraoral arch bars to maintain intermaxillary fixation.

The dogs were sacrificed and bilateral dissections revealed a relatively normal range of motion, add a viable condyle above the healed fracture site with a smooth glistening, articular surface. Microscopically both operated and unoperated sides revealed the normal histological pattern of the temporomandibular joint.

Walker (1960) reported on a study of mandibular condylar fracture dislocations in mine young Macaca rhesus monkeys. He found that the final results of condylar reformation were comparable whether conservative or surgical treatment was utilized and that reconstruction of the condyle was not hindered, to any degree, by early mobilization of the jaws.

Heurlin, et al (1961) studied the skeletal changes following fracture dislocations of the mandibular condyle in four adult Macaca rhesus monkeys. Two of the monkeys had unilateral fracture dislocations, and two had bilateral fracture dislo-

cations. The animals were sacrificed at six months. An anterior open-bite had developed in the bilaterally operated animals, while the occlusion remained unchanged in the unilaterally operated animals. On examination the temporomandibular joint of the operated sides revealed no evidence of ankylosis. The authors concluded that, "although mandibular growth does not cease entirely, the pattern of growth is changed so that development takes place by apposition and resorption under the influence of functional stress".

Guccione (1965), performed bilateral and unilateral condylectomies on six young Macaca rhesus monkeys. Three were operated unilaterally, three bilaterally and two served as controls. One monkey from each of the operated groups was sacrificed at two, four and six months. The controls were sacrificed at six and eight months, respectively. He found that the bilaterally operated animals developed an anterior open-bite as early as two months post-operatively. He further found that functional reconstruction of the condyle occured within four months after condylectomy.

Kaczala (1965), performed unilateral and bilateral intracapsular, subcondylar fracture dislocations on six young Macaca rhesus monkeys. One animal from each group was sacrificed at two months, another pair at four months, and the third pair at six months. Two animals served as controls and were sacrificed at four and six months, respectively. He found that all fractures healed without fixation or reduction. Masticatory

function and mandibular movements remained essentially normal. The two and six months bilaterally operated animals showed a loss of incisal relation which progressively increased in the six months specimen. The capsules of all operated sides were found to be fibrotic and larger in size than the unoperated sides or control animals. All condyles were active in endochondral bone formation.

Boyne (1967), used twelve young Macaca rhesus monkeys in his study. All had surgically induced subcondylar fractures. Four monkeys had open reductions and intermaxillary immobilization, four had no treatment. One monkey from each group was sacrificed at eight and twelve weeks and two from each group at sixteen weeks. Tetracycline labeling was used in each monkey in order to study the chronological growth and repair pattern.

Flourescent studies revealed continuous cartilagenous proliferation at the head of the condyle in all specimens and bony union at the fracture site was noted in all specimens regardless of treatment.

Hayes (1967), performed unilateral condylectomies on nine male rats and sacrificed them at regular intervals between eleven and forty-three days. He found no apparent ankylosis or mandibular disability. In six of the animals he noted that there had been regeneration of the condyloid process. He further stated that in those rats in which the condyle did not regenerate the surrounding capsular structures had been removed along with the condyloid process.

Schoen (1966), in his investigation, used seven young Macaca rhesus monkeys. Two monkeys had fracture and reduction and fixation of the condyles, one monkey had a unilateral condylectomy, one monkey had bilateral condylectomies, two had fracture dislocations and one animal served as control. The monkeys were sacrificed twelve months post-operatively.

The monkeys which had sustained bilateral condylectomies demonstrated a malocclusion, failure to reconstruct the condyles and retarded growth of the zygomatic arch. The monkey which had sustained a unilateral condylectomy developed an open-bite, and underdeveloped zygomatic arch and a fibrous "hinge-like" articulation.

All of the animals with fracture dislocations healed with or without treatment and growth of the mandible continued uninterrupted.

MATERIALS AND METHODS

The animals used in this study were eight young Macaca rhesus monkeys, obtained from the Shamrock Farms, Inc.Middletown New York. Six were males and two were females. The age of these animals, based upon their dentition add weight, ranged from four to six months of age.

Three of the animals had bilateral fracture dislocations of the mandibular condyles, three had unilateral fracture dislocations and two served as controls. These fractures were reduced, surgically, by means of transosseous stainless steel wire. The animals were operated in pairs, one unilaterally and one bilaterally.

The animals were maintained in stainless steel cages and their diet consisted of Rockland Primate Diet supplemented by fresh fruits and vegetables.

The operated animals were sacrificed in pairs, at two, four and six months, respectively. The controls were sacrificed at four and six months.

On the day of surgery the animals, were removed from their regular cages and placed into a spedially constructed "squeeze-cage". They were weighed and the amount of anesthetic (I.V. Nembutal Sodium-Abbott) necessary was calculated. (50 mg. /15 lbs. of body weight). By means of the "squeeze-cage" the animals were immobilized and the anesthetic administered via the Saphanous vein. The I.V. was maintained with 5% Dextrose

and water solution as it was necessary, in some cases, to supplement the original dose of anesthetic drug. Antero-posterior and right and left cephalometric radiographs were then taken using a cephalometric head holder, with Kodak medical x-ray film (Blue brand) in Kodak 8 by 10 cassette wutg a double intensifying screen. The target-film distance was 39 inches with an exposure time of 1.75 sec. at 115 kilovolt peak and 15 milliamperes. The monkeys' weight and dental record including deviation from the normal were then recorded.

The monkey's head was then shaved and scrubbed with soap and water. Ophthalmic Butyn Sulfate 2% and Metaphen 1:3000 (Abbott) was then placed into the eyes of the animals to prevent dessication. The animal was then draped with sterile drapes. A strict sterile technique was adhered to throughout surgery.

With a number of 15 Bard-Parker blade, a 3 cm. vertical pre-auricular skin incision was made. By means of sharp and blunt dissection the capsule of the joint was exposed. A longitudinal incision, parallel to the fibers of the capsule, was then made and the capsule reflected. Using #700 tapered fissure bur in a dental handpiece, with normal saline irrigation, a surgical fracture was produced just above the inferior portion of the capsule. The fracture was then reduced by means of a single 25 gauge stainless steel transosseous wire. The wound was then closed in layers with 4-0 chromic deep sutures and 4-0 silk skin sutures. Over the silk sutures several applications of plastic bandage (Resifilm-Squibb) was applied.

Prophylactic intramuscular injection of 600,000 units of long acting Bicillin (Wyeth) and 300,000 units of Wycillin (Wyeth) were given immediately following the completion of surgery.

Post-operative x-rays were then taken and the monkey placed into its cage and observed until it regained consciousness. Daily examinations of all of the animals was done.

At two months intervals, antero-posterior and right and left cephalometric x-rays were taken. In addition, the weight and dentition and occlusion were recorded.

The monkeys were sacrificed by injecting a lethal dose of Nembutal Sodium intravenously, followed by a solution of 10% buffered formalin via the right and left common carotid arteries to obtain immediate fixation of the entire head. The animals were then weighed and the occlusion and dentition noted. Following this, the temporomandibular joint was dissected and removed in its entirety for histologic study.

The tissue blocks were decalcified in a 10% solution of formic acid (for approximately two weeks), washed for twelve hours in water, dehydrated with increasing concentration of ethyl alcohol, cleared in chloroform and infiltrated with and imbedded in paraffin. Frontal sections were made of the right temporomandibular joint and saggital sections of the left side. The cuts were made at six microns and stained with hematoxylin and eosin.

FINDINGS:

All of the animals survived the experimental surgical procedure. Their post-operative courses were uneventful except for moderate post-operative edema, at the site of surgery, lasting for four to five days. None of the animals exhibited any signs of facial nerve damage or post-operative infection.

The monkeys were able to tolerate their normal diet within three days after surgery. No gross discrepancies of facial growth or symmetry were noted. No deviation in mandibular movements was noted, during mastication, in any of the animals. The occlusion remained normal in all of the animals studied. As revealed by the weight charts (Appendix A) all animals thrived well post-operatively.

The antero-posterior post-operative X-rays, taken at two months intervals revealed symmetry of the facial skeleton in all of the monkeys. (Appendix B) In the condylar region a typical growing condyle was observed which maintained the normal morphology. The only abnormal finding being the transosseous wire in the operated animals.

In all of the operated animals, histologic findings of the temporomandibular joint was comparable to those of the controls. The articulating surfaces were covered by avascular fibrous tissue. Beneath this layer of fibrous tissue was found the hyaline cartilage. In the deeper layers the chondrocytes were

greatly enlarged and the inter-cellular substance was deeply stained (degeneration and calcification of cartilage.) The deepest layer of the hyaline cartilage exhibited calcification.

The articular fossa was covered by a thin layer of fibrous tissue. Between the condyle and the articular fossa was seen the articular disc or meniscus, composed of dense connective tissue with bundles of collagenous fibers running in all directions. Immediately above and below the disc the upper and lower articular spaces or compartments were noted.

The fracture sites were not demonstrable histologically in any of the operated animals. However, gross examination at sacrifice revealed normal healing and repair of bone.No gross deformities were found and the transosseous wires were found to be imbedded within the substance of the bone.

DISCUSSION

In this study, the normal anatomic relationship of the temporomandibular joint was restored, following unilateral and bilateral surgical fracture dislocations of the mandibular condyle in young Macaca rhesus monkeys. The temporomandibular articulation, in the Macaca rhesus monkey differs from that of human in that the condylar neck is shorter, the glenoid fossa shallower, there is less prominent eminence and a larger post glenoid process.

In all of the operated monkeys the histologic and gross findings were comparable to those of the controls. The only abnormal finding being the transosseous wire in the operated monkeys.

Reconstruction of the condyle did not appear to be affected by allowing the jaws to be mobilized and functional post-operatively. This may be explained by the fact that the monkeys did not resume a completely normal diet until three days post-operatively and had limited function for an additional one to three days due to the attendant post-operative edema and trismus. Since callus formation in the young is rapid this short period of limited function and early mobilization may account for the excellent post-surgical results obtained in this study.

Predominant thought, for the treatment of fracture dislocations of the mandibular condyle, has tended to be conservative. However, a review of the literature reveals that while good

results are usually obtained by conservative treatment, there remain those cases in which some degree of morbidity has resulted. This may manifest itself as an open bite, deviation to the affected side upon opening, limitation of normal mandibular motion, retarded growth or ankylosis. It would, therefore, seem that the fine results which may be obtained by open reduction certainly justify its use.

SUMMARY AND CONCLUSION

SUMMARY:

In this study six young Macaca rhesus monkeys were subjected to unilateral and bilateral fracture dislocations of the mandibular condyle, followed by open reduction and fixation with transosseous stainless steel wire. Three monkeys were operated bilaterally, three unilaterally and two served as controls.

The animals were sacrificed in pairs, at two month intervals. The controls were sacrificed at four and six month intervals. In all of the operated monkeys the radiographic, histologic and gross findings were comparable to those of the control animals.

CONCLUSION:

Unilateral and bilateral fracture dislocations of the mandibular condyle in young Macaca rhesus monkeys heal without gross or histologic changes when the normal anatomic relationship is restored by means of open reduction and fixation.

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TABLE I

Wgt.	0 - Days	2 - Months	4 - Months	6 - Months.
1 UR	6 lbs. 12 Oz.	6 lbs. 14 oz.	7 lbs.	7 lbs. 2 oz.
2 B	4 lbs. 7 oz.	5 lbs.	6 lbs.	7 lbs. 14 oz.
3 UR	6 lbs. 9 oz.	6 lbs. 15 oz.	7 lbs.	
4 B	5 lbs. 4 oz.	6 lbs. 3 oz.	7 lbs.	
5 UR	5 lbs. 2 oz.	5 lbs. 4 oz.		
6 B	4 lbs. 8 oz.	4 lbs. 12 oz.		
C 1	4 lbs. 13 oz.	5 lbs. 2 oz.	5 lbs.	
c 2	4 lbs. 8 oz.	4 lbs. 15 oz.	5 lbs.	6 lbs. 1 oz.

Denti-tion				
1 UR	Deciduous	Deciduous	Mixed	Mixed
2 B	"	"	Mixed	Mixed
3 UR	"	"	Mixed	
4 B	"	"	Mixed	
5 UR	"	"		
6 B	"	"		
C 1	"	"		
C 2	"	"		
	"			

Occlu-sal De-fects				
1 UR	None	None	None	None
2 B	"	"	"	"
3 UR	"	"	"	
4 B	"	"	"	
5 UR				
6 B				
C 1			"	
C 2			"	"

Figure I

Photograph of post-operative radiograph (antero-posterior view) demonstrating the transosseous stainless steel wire in the unilaterally operated animal at sacrifice. (six months).

Figure I

Figure 2

Photograph of post-operative radiograph (antero-posterior view) demonstrating the transosseous stainless steel wires in a bilaterally operated animal, at sacrifice. (six months).

Figure 2

Figure 3

Photograph of post-operative radiograph (antero-posterior view) demonstrating the transosseous stainless steel wire in a unilaterally operated animal, at sacrifice. (four months).

Figure 3

Figure 4

Photograph of post-operative radiograph (antero-posterior view) demonstrating the transosseous stainless steel wires in a bilaterally operated animal, at sacrifice. (four months).

Figure 4

Figure 5

Photograph of post-operative radiograph (antero-posterior view) demonstrating the transosseous stainless steel wire in a unilaterally operated animal, at sacrifice. (two months).

Figure 5

Figure 6

Photograph of post-operative radiograph (antero-posterior view) demonstrating the transosseous stainless steel wires in a bilaterally operated animal, at sacrifice. (two months).

Figure 6

Figure 7

Photograph of radiograph (antero-posterior view) of control animal at sacrifice. (four months).

Figure 7

Figure 8

Photograph of radiograph (antero-posterior view) of control animal, at sacrifice. (four months).

Figure 8

Figure 9

Photomicrograph of left temporomandibular articulation of bilaterally operated animal (six months) specimen. demonstrating:

A. Temporal bone.
B. Articular disc.
C. Avascular fibrous tissue.
D. Hyaline cartilage.
E. Bone trabeculae.

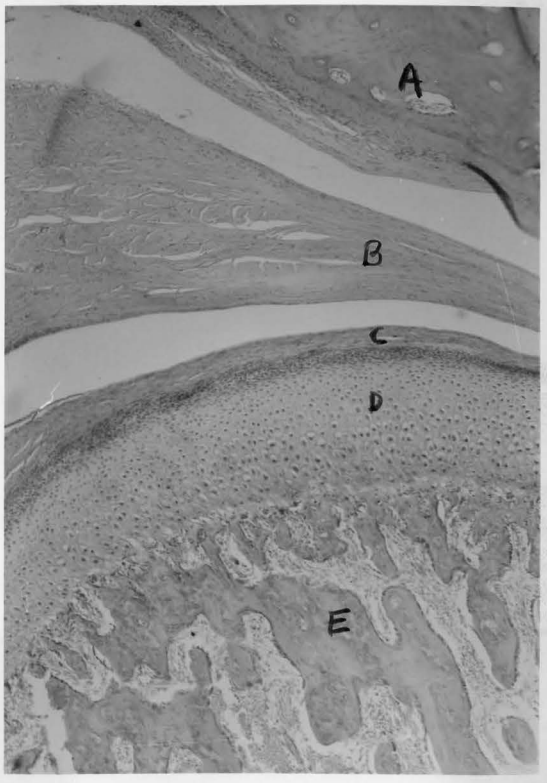

Figure 9

Figure 10

Photomicrograph of right temporomandibular articulation of bilaterally operated animal (six months specimen) demonstrating:

A. Temporal bone.
B. Articular disc.
C. Avascular fibrous tissue.
D. Hyaline cartilage.
E. Bone trabeculae.

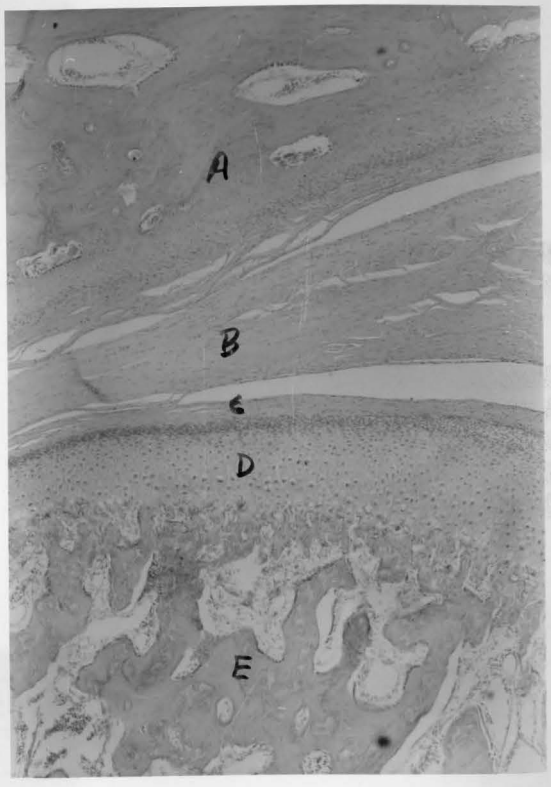

Figure 10

Figure 11

Photomicrograph of temporomandibular articulation of six months control animal, demonstrating:

A. Temporal bone.
B. Articular disc.
C. Avascular fibrous tissue.
D. Hyaline cartilage.
E. Bone trabeculae.

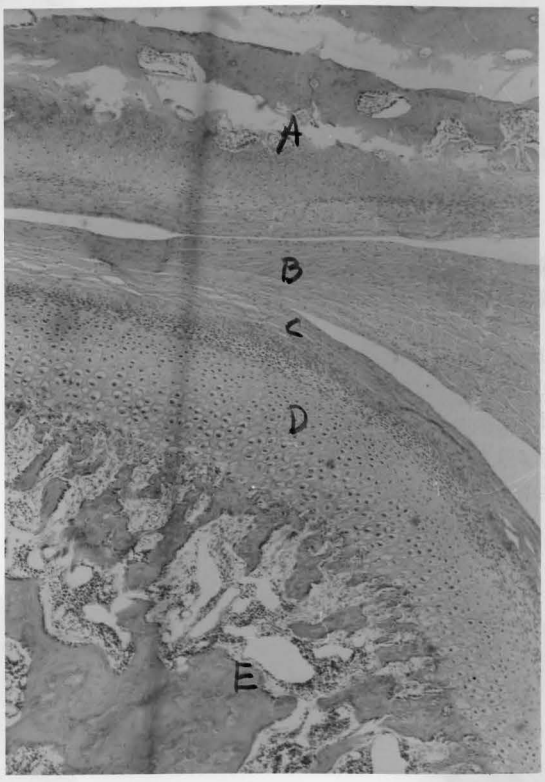

Figure 11

APPROVAL SHEET

The thesis submitted by Dr. Stephen J. Atsaves has been read and approved by the examining board of the faculty of the Graduate School.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Science.

May 23, 1969
Date

Patrick D. Testa
Signature of advisor