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THE ROLE OF THE CONDYLE IN THE
MANDIBULAR GROWTH

by

V.M. Sanghani

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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CHAPTER I
INTRODUCTION

Growth at the condylar region permits the body of the mandible to assume the proper balanced position in the face. The growth at the condylar region and the eruption of the teeth occur at related pace, however, this harmony of growth may be due to independent growth potentials of various structures involved or may be interdependent.

Inter-relation of various factors involved in this harmonized growth could be analyzed if growth activity at the condylar region is disturbed. The purpose of this investigation is to study the following changes in the mandible inducing disturbance at the condylar region by condylectomy.

A. Growth of the ramus of the mandible in an antero-posterior direction which is correlated with the space necessary for the successive eruption of the posterior teeth.

B. Growth of the body of the mandible in height, which is correlated with the vertical eruption of the teeth.

C. Change in the length of the mandible, which is correlated with the normal jaw relationship.

CHAPTER II

REVIEW OF THE LITERATURE

About thirty years before the published works of Sir John Hunter the use of vital staining in the study of bone growth was discovered. (Scott, 1938). Since that time many investigators have made contributions to the literature which dealt with improvements upon original technique, and also quite different methods of study, all of which have been designed to aid in the understanding of bone growth.

John Hunter in his work "On the Natural History of Human Teeth", (1771) first discussed the growth of the mandible. He stated that it increased in length only at the posterior border, by the apposition of new bone, while the ramus including the processes was at the same time remodeled by absorption of the front of the coronoid and to a lesser extent of the condyle. This process not only preserved the shape of the bone but also provided room for the developing molars, which in succession made their appearance on the inner side of the root of the coronoid. Hunter also stated that the height of the mandible was gained principally by addition of alveolar bone, an act which he thought closely associated with the eruption of the teeth. He did not attach significance to the condyle as a growth center, but thought it to be passively "lengthened in the same proportion"

as the alveolar bone. Hunter's observations were based mainly on madder feeding and osteometry in pigs.

Kolliker (1853) stated that "In the condyle of the inferior maxilla even during the fetal life, a thick cartilagenous layer is deposited, which so long as the growth of the bone continues, precedes its longitudinal growth, exactly like an epiphyseal cartilage."

Tomes (1859) recognized that there was no interstitial growth in the mandible. He observed in human material that the height of the jaws increased mainly due to apposition of alveolar bone. A factor helping to increase the height of the jaws and maintaining proper occlusion of the teeth, which became malaligned due to alveolar growth, was the slow but constant elongation of the ramus due to growth of the articular process of mandible. This growth, he thought, was in perfect harmony with the general law of ossification in temporary cartilage elsewhere in the body.

Humphry (1864) inserted two wires through holes in the anterior and posterior edges of the mandibular ramus of young pigs. He found, when the pig was killed after two months, that the ring fixed to the anterior edge of the ramus had disappeared from the mandible as a result of resorption, while the ring fixed to the posterior edge of the ramus was at considerable distance from the posterior edge and was completely embedded due to bone apposition.

Coyer (1901) as supporter of the theory of interstitial growth states: it is likely that the mandible growth by an interstitial growth at three fixed points viz: the ramus, the mental foramen and gnathion, and growth occurs between these points though time of the growth between these three points is not concurrent.

Fawcett (05, '24) noted the presence of a wedge shaped cartilagenous condyle which was transformed into bone as soon as it was formed. But he overlooked its significance for the growth of jaws and face.

Low (1909) studied serial sections of fetal heads and described the presence, histological appearance and mode of ossification of the condylar cartilage. But he, too, failed to attach to it any significant role in the growth of mandible.

Keith and Campion (1922) conducted a study by means of roentgenography and osteometry and concluded that upper facial growth was the "pace maker" to which the mandibular mechanism had to adapt. They suggested that the condyle could possibly contribute a substantial part to mandibular growth.

Brash ('24, '28) fed madder to young pigs. He noted that the "mandible grows by extension of its borders in all directions except along the anterior border of the coronoid process; the extension backwards of the ramus and upward of the condyle is noteworthy, as well as the smaller additions all along the lower border." He concluded that the mandibular molar moved upwards,

forwards, and outward.

Charles ('25, '30) was the first to conclude: "the mandible grows by additions to the base of the cartilagenous wedge or cone of chondroblast bone, which appears at the 55mm stage of the fetal life. The growth of the angle and coronoid process is subsidiary to the main line of growth of the wedge which is in an upwards, outward and backward direction, the mandible therefore traveling in a downward and forward direction."

Todd (1926) believes that interstitial growth is characteristic of the jaws and agrees with the belief that there is a change in relationship between the face and the cranium during childhood and adolescence that results in the face "emerging more and more from beneath the brain case."

Todd ('25, '30, '32) contradicted the apposition theory of mandibular growth and postulated that mandibular growth was interstitial.

Brash (1934) continued his madder feeding experiments and changed some of his previous opinions. He now thought that the mandible grew chiefly by surface apposition, which occurred mainly on the lateral aspect and extended the posterior border backward and the condyle upward and backward. There was both forward and backward growth of the mandible, the former occurring at the anterior surface in the symphyisial region and the latter at the posterior border, extending from the condyle to the angle.

Along with growth of the mandible, modeling resorption occurred exactly as in the case of long bones.

Baker (1937) in reporting a series of transplantations of embryonic mandible of rats in the eyes, leg muscles and brain, of other rat, states that "the mandible has increased in size by two groups of forces one inherent in the germ-plasm and operating before birth, the other functional; and operating after birth.

Thoma (1938) discussed several clinical case histories and concluded: "The development of the mandible seems therefore to be influenced principally by muscular function and its associated increased collateral blood circulation, and because the most powerful muscles are attached to the ramus, its growth occurs principally in the posterior border."

Scott (1938) performed an experimental study with pin implants in dogs' mandibles and took various measurements. He concluded that vertical height was gained by lengthening of the ramus, addition at the inferior border and addition of alveolar bone. He also stated that there was antero-posterior growth between mental foramen and anterior border of coronoid, though there was resorption at the anterior border of coronoid and apposition at the posterior border. According to Scott this technique was also used in the past by Dulmel, Ollier, Proell and Wyswell.

Sicher and Weinmann (1944) used anatomic, roentgenographic and histologic methods combined with alizarin injection in rats and concluded that the mandible grew in length at the condyle and at the posterior borders; the ramus grew in height at the condyle and at the tip of the coronoid process, and the body at the free borders of the alveolar process.

Rushton (1944) supported Wilson Charles' (1930) view on the role of the condyle as a growth center of the mandible. He came to the conclusion, based on histological and clinical evidence, that the condyle acted as an active growth center up to the second decade of life, after which the activity ceased. In 1948, Rushton administered an excess of estrogen to kittens and produced arrest of condylar activity, as proved histologically. The growth of mandible and face were arrested. Rushton concluded that, since the action of estrogen is specific on growing cartilage cells, the main center of mandibular growth was in the condyle.

Clark (1945) stated that bone never grew by interstitial growth, but always by apposition.

Engel and Brodie (1947) noted the similarity between condylar growth and the epiphysis of long bone. Injury to condylar growth center during the growth period causes arrest of growth and consequent distortion of the mandibular form.

Sicher (1947) supported Clark's view and further stated that

though cartilage could grow by both processes, it grew by apposition only when covered with connective tissue. In young individuals condylar cartilage grew both by interstitial growth and apposition from the deepest layer of its connective tissue covering. As the condyle grows, a space is created between the jaws which is soon filled up by growth of both jaws.

Jarabak and Graber (1951) noticed that the facial height of rats (measured from the occlusal surface of the molars to the apex of the ethmoid) increased as a result of bilateral resection of the condyle. They suggested that the change might be due to an increase in the angle of the occlusal plane. The study was done with cephalometry.

Symons (1951) made a comparative anatomic study of superimposition of roentgenographs. He noted that there was a continuous addition of bone at the condylar end of the mandible by ossification of rapidly proliferating cartilage cells. He argued, however, that the lower teeth were not carried on the mandible but on a bony process, the alveolar process, which is a tooth bearing bone and which grows independently and differently from the mandible.

Jarabak and Thompson ('51, '53) performed bilateral condylectomy in rats and used serial cephalometric radiographs. They stated that the length of the mandible (from the distal spine of the angle to the superior alveolar crest of the incisor) and the

height of the ramus (from the tip of the coronoid to the spine of the angle) were not perceptively affected due to the loss of the condyle.

Scott (1951) after a comparative anatomic study in dog, sheep and pig concluded that the jaw grew by apposition at the symphysis and back of the ramus. There was no evidence of extensive absorption at the base of the coronoid. Growth of the lower jaw downward and forward was result of growth of cartilage of the condyle.

Walpole-Day (1951) studied the condylar region by means of roentgenography, histology, and clinical histories of deformed mandibles of man. He stated that the condyle was responsible for more than half of the forward displacement (length) of the body of the mandible: "Growth of the condyle is the most important single factor in the co-origination of growth of the two jaws to produce a normal occlusion of the teeth."

Weinmann and Sicher (1955) stated that the "condyle persists as the most important growth center of the mandible...by condylar growth the overall length of the mandible increased, but not the length of the mandibular body; not...the anteroposterior width of the ramus itself. Here appositional growth along the entire posterior border of the ramus is the mechanism for adjusting the width of the ramus and the length of the body..." They also stated that the "apposition of bone at the lower mandibular

border is negligible."

Robinson and Sarnat (1955) studied the growth of the pig mandible by metallic implants and superimposition of roentgenographs. They noted that the distance between the implants remained the same. Apposition was seen at the posterior, alveolar, inferior and anterior borders and at the lateral surfaces. The sites of maximal growth were condyle and posterior border.

Ludwig (1958) using alizarin in bilaterally condylectomized rats, measured eruption and drift from ground sections of the molar bearing areas. The animals ranged from 36 to 75 days of age. He found that eruption and drift in the operated groups were 66 to 69% of those of the controls.

Tomek (1959) performed both bilateral and unilateral condylectomy in young Macaca Rhesus monkeys. Roentgenographs were taken one week before surgery, immediately after surgery, and at six months' intervals post-operative up to 17 months. He concluded that the ascending ramus ceased to grow and that there was facial deformity in the operated animals.

Jolly (1961) performed bilateral condylectomy in young and mature rats and studies the reparative process by serial histological section and roentgenography. He found that there was little loss of mandibular function. The mandible was displaced slightly posteriorly. There was early recovery and formation of a new functional joint, a callus forming around the mandibular

stump and bone formation starting as early as six days. A new center of bone formation was noticed slightly below the condylar area.

Evaluation of the literature revealed attempts to study the role of condyle in mandibular growth has been done in the past. Such studies were done in animals keeping the condyle intact, and by removing condyle with surgical technique. Both of these methods for studying the role of condyle have been contributory, but it is felt that the the condylectomy remains the method of choice as the resulting sequence of events leads itself to specific interpretation.

Most workers in the past, attempted to study with older animals. Present work deals with younger animals, taking advantage of the faster growth rats. This approach could be more rewarding towards the understanding of the role of condyle in mandibular growth.

CHAPTER III

MATERIALS AND METHODS

The present study is based on materials obtained from 40 male albino rats. All the animals in the present study were of 10 days + 1 of age. Ten animals that were 10 days old were killed, and served as base line control in the experiment. The rest of the animals were divided into an equal number of experimental and control groups. Bilateral condylectomy was performed on the experimental group. At the end of the 6th week after condylectomy, all the experimental animals along with the controls were killed.

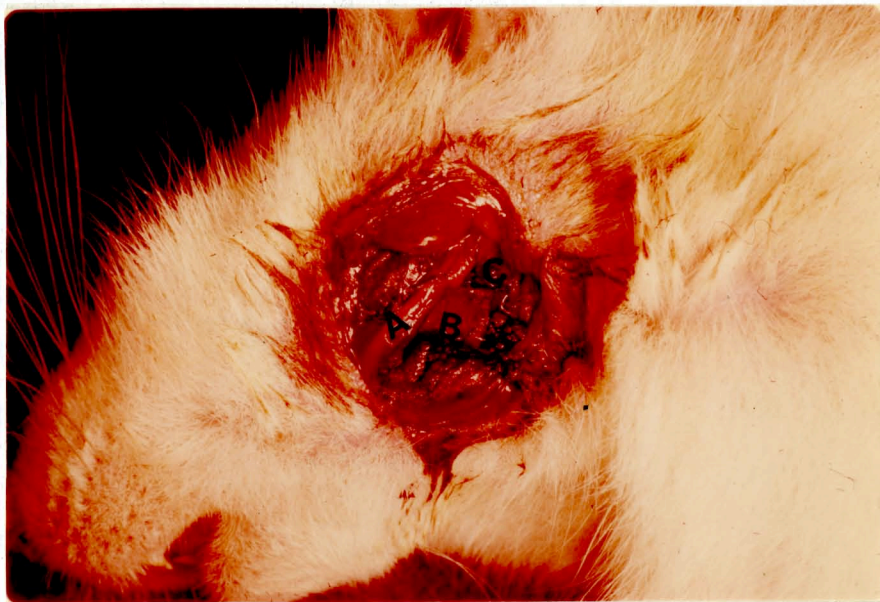
Anaesthesia

Intraperitoneal injection of 0.3% Sodium Peritobarbital solution in 10% ethyl alcohol was used as anaesthetic agent. Dose given is .01 cc per 10 gms. of body weight. Microsyringe (accurate up to .001 cc) was used for injecting the animals. It took about 3-5 minutes to induce anaesthesia, the effect lasted for about 30 minutes, time sufficient to perform the entire surgery.

Surgical Procedure

The hair over the operating area was shaved and the skin prepared with tincture of iodine and alcohol. Clean instruments and drapes were used.

When the animal was anaesthetized, it was placed on its



Photograph No. 1

A = Zygomatic Arch
B = Ramus
C = Condylar Area

abdomen with its head to one side. A vertical incision was made, as it gives better access and less trauma to the area than a transverse one.

Incision was placed about 5mm in front of the external auditory meatus, and was about 10mm long, extending for almost equal distance on both sides of the zygomatic archs (Photograph No. 1). The incision cut through the skin, superficial fascia and platysma muscle and exposed the orbital lacrymal gland, branches of the facial nerve, superficial temporal vessels and parotid duct. The overlying transparent fascia is cut and reflected from exorbital gland. The lower border of this gland is gently separated from deeper structures and reflected upwards. The fascia above the lower zygomatic branch of the facial nerve and the superficial temporal vessels is divided carefully. By blunt dissection a pair of mosquito forceps is passed between and gently separated the inferior fibres of the masseter muscle. A pair of curved mosquito forceps is passed through this space and the neck of condyle grasped as close to the head as possible. The condyle in all the cases was identified by moving the anterior end of the mandible. The neck of the mandible is divided just below the forceps with a pair of small curved scissors. The lateral Pterygoid muscle is then carefully separated from the severed condyle and the condyle removed. Hemorrhage, if any, was controlled by using gel foam and local pressure. The wound was closed with

0.5 nylon sutures.

Post-operative Care

The animals recovered within a half hour but were lethargic for the rest of the day. The body weight was checked periodically. The wounds were checked periodically for signs of infection. The sutures were left in place.

Autopsy Procedures

The animals were killed by an overdose of anaesthesia with ether. The operated area was examined for presence of infection. The jaws were examined for symmetry, extent, and freedom of passive movement. The heads were severed, skinned, and kept in 10% buffered formalin solution for 24 hours or longer. Mandibles, later on, were disarticulated and measured.

Methods of Measurement (Photograph No. 2)

(A) Mandibular Length (L):

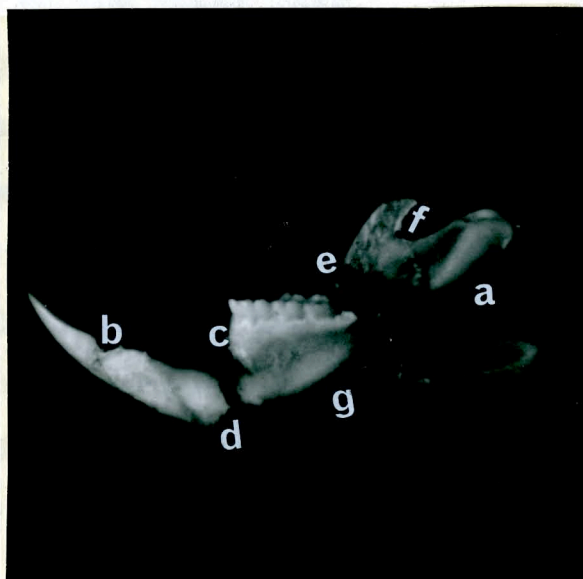
From the point on the deepest concavity on the posterior border of the ramus (a), to the point on the most anterior part of the alveolar process of the lower incisor (b).

(B) Height of the Mandibular Body (H):

Point on the antero-superior part of the alveolar process of the first molar (c), to the point on the inferior border of the body, which is on a plane vertical to the alveolar plane (d).

(C) Width of the Mandibular Ramus (W):

From the point on the deepest concavity on the posterior



Photograph No. 2

- a = Point on the Deepest Concavity on the Posterior border.
- b = Point on the most Anterior part of the Alveolar Process of the lower Incisor.
- c = Point on the antero-Superior part of the Alveolar Process of the first molar.
- d = Point on the Inferior border of the Mandible.
- e = Point on the anterior border of the ramus.
- f = Point on the Deepest Concavity of Sigmoid notch.
- g = Point on the Deepest Concavity on the inferior border of the Mandible.

border of the mandible, to the point on the anterior border of the ramus, on the straight line extending from the first point through inferior part of the mandibular foramen. (e)

(D) Distance of the Molar (M):

From the point on the deepest concavity on the posterior border of the ramus, to the point on the antero-superior part of the alveolar process of the first molar.

(E) Height of the Mandibular Ramus (R):

From the point on the deepest concavity of the Sigmoid notch above (f), to the point on the deepest concavity on the inferior border of the mandible (g), below.

CHAPTER IV

FINDINGS

Base Line Control:

Ten animals 10 days old were used as the base line control. Gross examination before the sacrifice of animals, revealed that lower incisors were quite aligned with the upper incisors, thus a straight line between lower incisors extending vertically upward would pass between the two upper incisors. Passive movement of the temporomandibular joint was free and unrestricted. Following the gross examination animals were weighed and sacrificed by prolonged anaesthesia. Heads were skinned and fixed in 10% formalin. Mandibles, later on, were disarticulated with due care.

Mandibles: (Base Line Control)

Mandible of the rat consists of two halves forming more or less a V shaped body which continues upward and backward into mandibular ramus. The ramus ends into two processes, the anterior coronoid and posterior condyloid process. Mandibular angle is formed by posterior border of the ramus and inferior surface of the body.

The body carries the alveolar processes. The alveolar processes and molars run from lateral to medial side antero-

posterior, thus a straight line extending from the central part of the molars on both sides would meet at an acute angle, posteriorly.

In the region of the mandibular angle on the lateral side, very prominent bony ridge called the massetric ridge, for the attachment of the masseter muscle.

Coronoid process is triangular bony plate ending in a sharp corner or elongated into small backward curved hook. Anterior border of coronoid process is convex which continues into the anterior part of the ramus. Posterior border of the coronoid process is concave. This area, on account of peculiar shape and tendinous attachment, needs a special caution, during disarticulation.

Condylod process is separated from the coronoid process by Signoid notch or sub-coronoid area. Condylod process is more medial to coronoid process. Smooth condylar head is connected to the ramus by the mandibular neck.

Weights and Measurements: (Base Line Controls)

Table I shows the Weights and Measurements of the Base Line Controls. Weights of the animals vary from 17 gms to 26 gms. With the average weight of 21 gms. Difference of the measurements between the two halves was negligible, which ranged from .1 to .3 mm. Table I shows the mean mandibular length (L) of each mandible. It varies from 14.1 to 15.0 mm, with the average

mandibular length (L) 14.6 mm. Mean Heights of the body (H) of the mandibles vary from 2.3 mm. to 2.8 mm. with average height (H) of 2.6 mm. Mean Width of the ramus (W) vary from 4.3 mm. to 4.7 mm. with the average width (W) of 4.4 mm. While the mean measurements from the point on the deepest concavity on the posterior border to the point on the antero-superior part of the alveolar process of the first molar (M) vary from 8.0 mm. to 8.8 mm. with the average of 8.4 mm. Height of the mandibular ramus varies from 5.1 mm. to 5.5 mm. with the average mandibular ramus height (R) of 5.2 mm.

WEIGHTS AND MEASUREMENTS

BASE LINE CONTROLS

TABLE I

No. of Animal	Weight (Wght)	Length (L)	Height (H)	Width (W)	Pt. On Deepest of Concavity of Post. Border of 1st Molar (M)	Pt. of Alv. Mandibular (R)	Height of the
1	26 gm	14.9mm.	2.8 mm.	4.6 mm.	8.7 mm.		5.3mm.
2	24	14.8	2.8	4.5	8.6		5.2
3	21	14.7	2.7	4.4	8.6		5.2
4	19	14.3	2.3	4.1	8.0		5.4
5	17	14.1	2.3	4.3	8.2		5.1
6	24	14.8	2.7	4.5	8.5		5.2
7	22	14.6	2.6	2.6	8.3		5.4
8	26	15.0	2.8	4.7	8.8		5.5
9	21	14.5	2.7	4.5	8.3		5.2
10	22	14.6	2.6	4.2	8.4		5.2

Base Line Control

POST-OPERATIVE FINDINGS

Control Animals:

All the animals in this group during 6 weeks experimental period showed weights proportionate to their age (Table IV). Gross examination of the animals before the killing revealed that lower incisors were quite aligned with the upper incisors. There was no shifting of the mid-line. The incisors were well abraded, and both lower incisors appeared of equal length. Passive movement of the temporo-mandibular joint was free and unrestricted. Following the examination animals were weighed and sacrificed by prolonged anaesthesia. Heads were skinned and fixed in 10% formalin. Mandibles, later on, were disarticulated.

Mandibles: (Control Animals)

Mandibles of the control animals were of normal shape and did not present any deformity.

Weights and Measurements: (Control Animals)

Table II represents the weights of control animals. It varies from 101 gms. to 142 gms. with average weight of 124.5 gms. Table IV presents the various measurements of the control animals. The mean lengths (L) of the mandibles varies from 17.9 mm. to 22.5 mm. with the average length (L) of 19.7 mm. Mean heights of the body of the mandibles vary from 4.0 mm. to 5.3 mm. with the average (H) of 4.6 mm. Widths of ramus vary from 5.8 mm. to 8.1 mm. with the average width (W) of 7.1 mm. While the measurements

CONTROL ANIMALS

WEIGHTS

TABLE II

0	10 days	14 days	18 days	22 days	27 days	32 days	37 days	42 days	47 days	52 days
1	26 gms	32 gms	42 gms	54 gms	67 gms	81 gms	94 gms	109 gms	212 gms	138 gms
2	26	33	44	57	71	84	99	113	126	142
3	24	32	41	52	64	78	91	105	116	131
4	21	28	36	47	60	74	86	98	110	122
5	21	27	35	47	61	73	86	98	111	123
6	20	26	34	45	59	70	84	95	109	121
7	21	27	34	44	58	68	83	93	108	122
8	17	23	30	41	54	63	70	79	99	101
9	22	28	37	48	61	76	88	101	111	124
10	24	32	41	54	66	80	93	109	121	137
11	19	25	32	43	57	68	81	92	104	116
12	19	26	34	44	58	69	83	93	108	120
13	20	25	33	43	57	69	81	92	105	117
14	23	30	39	50	62	79	90	104	114	132
15	23	29	38	49	60	77	87	102	111	124

EXPERIMENTAL ANIMALS

WEIGHTS

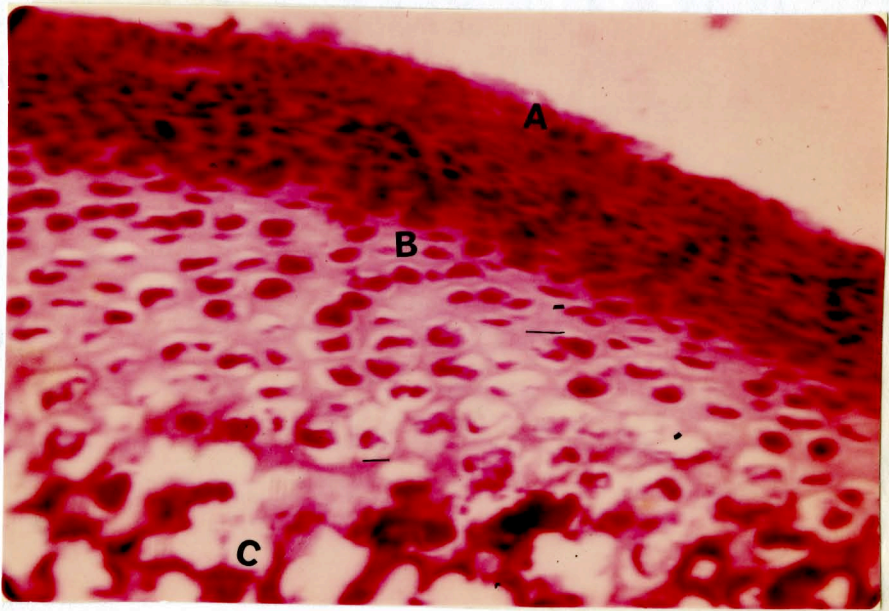
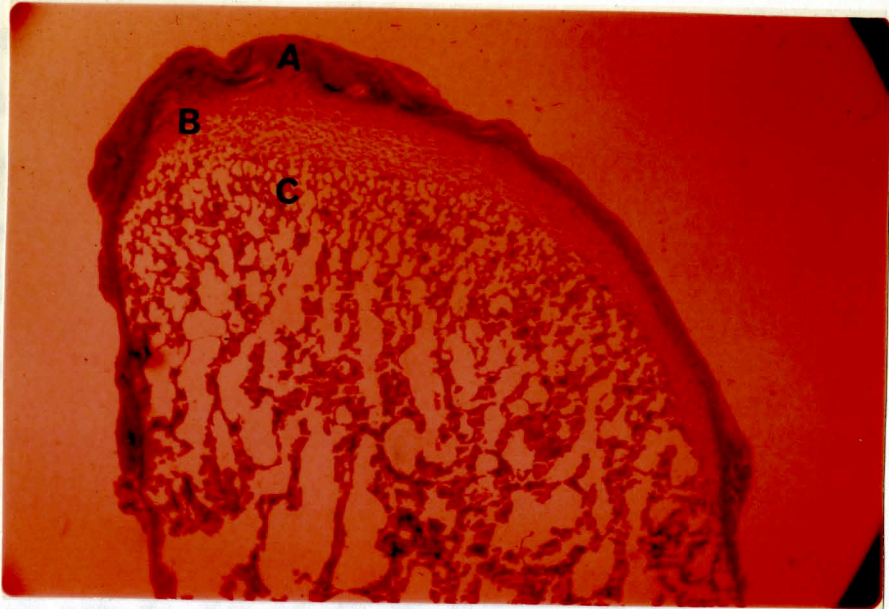
TABLE III

0	10 days	14 days	18 days	22 days	27 days	32 days	37 days	42 days	47 days	52 days
1	26 gms	31 gms	37 gms	51 gms	65 gms	79 gms	93 gms	109 gms	120 gms	136 gms
2	27	32	43	56	72	86	102	116	129	147
3.	25	30	40	52	66	82	95	109	121	137
4	21	26	35	46	60	75	86	99	111	123
5	21	26	34	45	58	74	87	100	112	123
6	19	24	31	43	57	68	81	92	103	117
7	20	25	33	44	59	69	83	95	108	122
8	16	20	27	39	53	62	68	76	87	99
9	22	27	35	46	60	76	89	101	110	121
10	24	29	36	50	64	80	93	108	120	135
11	20	25	32	44	58	69	82	93	105	117
12	19	24	32	43	57	69	83	94	108	119
13	20	25	33	44	57	69	81	93	104	118
14	22	26	35	45	58	74	88	100	112	126
15	23	28	37	47	59	77	89	103	113	127

WEIGHTS AND MEASUREMENTS OF
CONTROL ANIMALS AT THE 6TH WEEK

TABLE IV

No. of Animal	Weight (Wt)	Length (L)	Height (H)	Width (W)	Pt. On Deepest of Concavity of Post. Border to Process of 1st Molar (M)	Pt. of Alv. Mandibular (R)
1	138 gm	22.5mm.	4.4mm.	8.1mm.	14.1mm.	9.3mm.
2	142	22.5	5.3	8.1	14.6	9.4
3	131	19.5	4.0	6.8	12.6	8.4
4	122	18.9	4.6	7.1	11.8	7.5
5	123	19.6	4.8	7.2	12.3	8.2
6	121	18.9	4.7	7.2	12.3	7.6
7	122	18.9	4.3	7.2	11.8	7.6
8	101	17.9	4.4	5.8	11.2	7.4
9	124	19.9	4.8	7.1	12.5	8.1
10	137	21.8	4.8	8.3	13.7	9.1
11	116	19.8	4.9	7.2	12.8	8.2
12	120	19.8	4.6	6.7	12.3	8.4
13	117	18.3	4.6	7.0	11.9	8.3
14	132	19.4	4.9	7.1	12.8	9.1
15	124	19.8	4.8	7.2	12.9	8.4



Photographs No. 3 and No. 4

- A = Fibrous tissue which covers condylar cartilago
- B = Cartilagenous area
- C = Bony Part

from the point on the deepest concavity of the posterior border to alveolar process of first molar (M) vary from 11.2 mm. to 14.6 mm. with the average (M) measurement of 12.6mm. Height of the mandibular ramus varies from 7.4 to 9.4 with the average mandibular ramus height (R) of 8.3 mm.

Experimental Animals:

Histologic findings of the surgically removed tissue: (Photographs 3 and 4).

Histologic view of the tissue shows three areas (A) fibrous tissue which covers the condylar cartilage (B) the area is cartilagenous in nature and structurally it is an hyaline cartilage (C) this area represents the bony part of the condyle. Structurally it is a cancellous bone, covered with a thin layer of compact bone.

Experimental Animals:

All the experimental animals started suckling within 24 hrs. after surgery. It was noticed that the weaning period in some of the operated animals was delayed by a day or two. (Normal weaning period, 14 to 15 days.) During the later period of the experiment, there was no apparent difference in dietic habit between the groups.

All the animals in this group showed weights proportionate to their age, except for initial fall in body weight. Initial fall in the body weight is partly due to trauma from surgery and

interference with feeding and masticatory function on account of condylectomy.

Gross examination, at the end of the 6th week period, revealed that lower incisors were aligned with the upper incisors, and there was no shifting of the mid-line, except in three animals. The lengths of the two lower incisors of the same mandible appeared the same. Passive movement of the temporo-mandibular joint and unrestricted.

Mandibles: (Experimental Animals)

Disarticulated mandibles, when examined, revealed some interesting features. The body of the mandibles apparently were of quite normal shape without any gross deformity. Condylar region of the mandible showed some remarkable variations (A) complete absence of condylar process. (Photographs No. 5 and 6); (B) Rough and ragged head of the mandible; (C) Smooth mandibular head just comparable to the normal control group.

Weights and Measurements: (Experimental animals Table V)

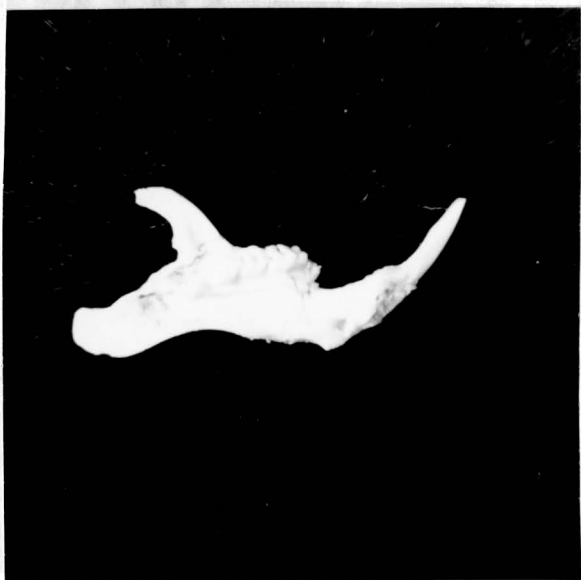
Weights in the experimental group at the end of the experimental period vary from 99 gms. to 147 gms. with an average of 124.4 gms. The mean lengths (L) of the mandible vary from 17.3 mm. to 23.0 mm. with the average (L) of 19.3 mm. The mean height (H) of the body of the mandibles vary from 4.1 mm. to 5.2 mm. with the average (H) of 4.5 mm. The mean width (W) of the ramus of the mandibles vary from 5.7 mm. to 8.2 mm. with an aver-

WEIGHT AND MEASUREMENTS OF
EXPERIMENTAL ANIMALS AT THE 6TH WEEK

TABLE V

No. of Animal	Weight (Wt)	Length (L)	Height (H)	Width (W)	Pt. On Deepest of Concavity of Post. Border to Alv. Process of 1st Mo- lar (M)	Pt. Height of Mandibular (R)
1	136gm	22.3mm.	4.4mm.	7.9mm.	14.7mm.	9.1mm
2	147	23.0	5.2	8.2	14.8	9.6
3	137	19.8	4.1	7.1	12.7	8.5
4	123	18.5	4.4	6.8	11.6	7.3
5	123	18.1	4.6	7.1	11.6	7.6
6	117	18.5	4.6	7.1	11.6	7.3
7	122	18.5	4.2	7.0	11.1	7.4
8	99	17.3	4.6	5.7	10.1	7.1
9	121	19.4	4.7	7.2	12.3	7.8
10	135	21.8	4.6	8.2	13.6	9.1
11	117	19.4	4.7	7.2	12.6	8.1
12	119	18.1	4.7	6.8	11.1	7.8
13	118	18.3	4.6	6.8	11.8	8.2
14	126	19.1	4.7	7.2	12.5	9.1
15	127	19.4	4.7	7.1	12.5	7.9

age (W) of 7.1 mm. Mean measurements from the point on the deepest part of the concavity on the posterior border to the alveolar process of the first molar (M) vary from 10.1 mm. to 14.8 mm. with the average (M) of 12.2 mm. Height of the mandibular ramus varies from 7.1 to 9.6 with average mandibular ramus height (R) of 8.0 mm.



Photographs No. 5 and No. 6

Specimens showing the Complete Absence of the
Condyle.

CHAPTER V

DISCUSSION

Development and growth of the body, orderly in time and genetically determined, is to a high degree dependent upon balanced diet and normalcy of the endocrine system. Skeletal growth though highly integrated with the body growth, is based on three factors: (1) Growth of the model tissue, (2) Growth of the bone, (3) Modeling resorption. (Sicher, 1952)

Though these factors are also active during the growth of the mandible, there are some special features which need discussion. While the cartilage in the mandibular condyle constitutes model tissue for the mandibular growth, it can not be compared with articular or epiphyseal cartilage. Most important difference is condylar cartilage growth mainly, if not all together, by apposition, while the epiphyseal cartilage grows by the interstitial growth.

In the present experiment an attempt has been made to find out the changes in the mandibular growth, by disturbing this growth mechanism by condylectomy.

Mandibular Length:

Statistical evaluation of this finding, at the end of the experiment, showed significant differences in mandibular length

between the control and the experimental groups. Length in control animals was more than the experimental animals, "t" value for this difference was 3.0147 indicating P 0.01.

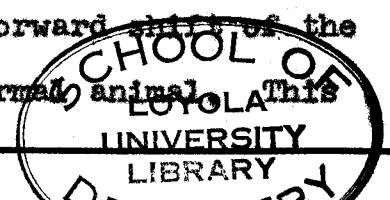
In the present experiment, mandibular length is measured from the most anterior point on the alveolar process of the incisor (anteriorly), to the deepest point on the concavity of the posterior border (posteriorly),

Jolly (1962) showed in the bilaterally condylectomized rats, that there was no difference in the length of the incisors after 28 days, between condylectomized and non-condylectomized group. This may be interpreted that changes anteriorly are minimal. Factors contributing to the difference of the mandibular lengths could be located posteriorly, in the present experiment. Das (1964) using alizarin in bilaterally condylectomized rats showed that appositional growth at the subcondylar area at the posterior border was 62% of the control group. Retardation of appositional growth on the posterior border (posteriorly) would lead to the difference in length, and would decrease the length of the condylectomized rats, as compared to controls.

Height of the Mandibular Body:

Statistical evaluation of the height of the mandibular body shows "t" value 1.980 indicating P 0.07. There is very little significance, which can be attached to this "P" value.

Condylar growth causes the downward and forward shift of the entire mandible from the cranial base in a normal animal. This



process in the normal animal is correlated with the vertical eruption of the teeth and concomitant incorporation of the alveolar process, vacated by moving teeth, increases the height of the mandibular body. There is apposition of the bone at the lower border which to the variable degree contributes to the height of the mandibular body.

In the condylectomized animals, in spite of the failure of the normal mechanism, the gain in height almost to the level of control could be explained on the following basis: (Baker, 1937) Structure of the mandible, under both control and experimental conditions, is dependent upon its function. Factors, such as muscles, tongue gain an influence upon the modeling of the mandible. Apposition of the bone at lower border of the mandible would increase due to the adaptive growth to provide the necessary strength to the mandibular body in condylectomized rats.

Width of the Ramus:

Statistical evaluation of the present findings at the end of the experiment, showed no significant change in the width of the ramus between two groups. The "t" value for this difference was 1.341 indicating P 0.05.

Appositional bone growth contributes significantly to the growth of the mandible. Deposition of the bone on the posterior border and resorption on the anterior border lengthens the body of the mandible. This mechanism is responsible for the successive

eruption of the teeth in the mandible. Ludwig (1958) using alizarin, in the bilaterally condylectomized rats, showed that the rate of the eruption was 66% of the controls. This is possible if the rate of resorption is decreased to the level.

As mentioned above, the rate of apposition (in condylectomized rats) on the posterior border being 62% of the control, going along with the resorption on the anterior border to the extent would not change the width of the ramus.

Molar Distance (M):

Statistical evaluation of the distance measured from the deepest point of the concavity on the posterior border to alveolar process of the first molar shows significant difference between control and experimental animal. "t" value for this difference is 2.947 indicating P 0.01.

This significant difference is due to the same factor which is responsible for the difference in the length. Reduction of the apposition on the posterior border in the condylectomized rats would decrease the molar distance of the experimental animals.

Height of the Mandibular Ramus (R):

Statistical evaluation of this finding, at the end of the experiment, shows significant difference between the control and experimental animals. Height of the mandibular ramus in the control animals is greater than that of experimental animals. "t"

value for this difference is 3.342 indicating P 0.01.

In the present experiment, height of the mandibular ramus is measured, from the point on the deepest concavity of the Sigmoid notch above, to the point on the deepest concavity on the inferior border below.

Factors contributing to the difference in the Mandibular ramus height between two groups, could be located, either at the Sigmoid notch, or at the inferior border of the mandible. The possibility of difference at the inferior border between two groups would be minimal, due to adaptive growth at the inferior border, in the condylectomized animals. (Baker, 1937).

During the period of growth, layer of hyaline cartilage lies underneath the fibrous covering of the condyle. This cartilagenous plate grows in upward and backward direction from the deepest layer of the covering connective tissue, at the same time, it is destroyed at its deep surface and replaced by bone in the downward and forward direction, (i.e. Sub-condyloid and Sub-coronoid area respectively). Condylectomy would disturb this normal sequence, and decrease the amount of deposition of bone in the Sub-coronoid (Sigmoid notch) area. This retardation of bone deposition at the Sigmoid notch, in the Condylectomized animals, would decrease the height of the ramus as compared to the controls.

Temporomandibular Joint

Function:

The four principal mammalian muscles of mastication, the temporal, masseter, medial and lateral pterygoids, are present in the rat. However, the rat being a rodent or gnawing animal, these muscles are adapted especially to give greater power and range in protrusive and incisive movements. The main adaptation is the relatively much larger masseter muscle of the rodent and the direction of the fibers of its anterior superficial head. The masseter muscle in the rat has four distinct parts. (Greene, 1935). The fibers of the large superficial part have an almost horizontal direction, due to the migration of the origin of this position to the infraorbital region of the maxilla. Running horizontally from the maxilla to the mandibular angle, this head of the muscle is the more powerful protruder of the mandible than the lateral pterygoid muscle, which in the rat is relatively small. Severance of lateral pterygoid muscle in condylectomy, therefore, does not disturb muscle equilibrium to the same degree in man, where it is the only protruding muscle.

Repair:

Repair of the condyle can not be separated from the repair of the temporomandibular joint due to anatomic intimacy of the structures. Jolly (1962) in his histologic study of the condylectomized rats showed that, (1) maintenance of the distance between the base of the skull and the cut end of the mandibular ramus,

(2) an early and vigorous response by the tissues resulting in the formation of a new articular process and the establishment of a nearthrosis, (3) early formation of calcifying tissues-immature spongy bone, cartilage or chondroid bone-in five discrete centers: a) around the mandibular neck, b) on the cut surface of the mandibular neck, c) at the severed end of the lateral pterygoid muscle, d) on the surface of the articular fossa, e) on the lateral wall of the cranium opposite the new articular process.

Free and unrestricted passive movement of the Temporomandibular joint, before killing the animals, rules out the possibility of ankylosis of the Temporomandibular joint in the present experiment.

CHAPTER VI

SUMMARY AND CONCLUSION

The purpose of this investigation was to study the role of the condyle in the mandibular growth.

The present study is based on the materials obtained from the 40 male albino rats. All the animals in the present experiment were 10 days \pm 1 day of the age. Ten animals, 10 days old, were used as the base line control to study the mandibles at this age group. The rest of the animals were divided into an equal number of the experimental and the control groups. Bilateral condylectomy was performed on the experimental group. At the end of the 6th week, after the condylectomy, all the experimental animals along with the controls were killed.

Following major observations were done between the control and the experimental group:

1. Weights of the animals.
2. Mandibular length.
3. Height of the mandibular body.
4. Width of the mandibular ramus.
5. Molar distance, which is the measurement from the point the deepest cavity on the posterior border to the point on the antero-superior part of the alveolar process of the first molar.
6. Height of the mandibular ramus.

7. Shifting of the mid-line.

8. Any apparent deformity in the mandibular body and ramus.

From the noted observations it is concluded that:

1. There was no difference in the weights between the two groups, except initial fall in weights of the experimental group.

2. Statistically, there was a decrease in mandibular length of the experimental group, as compared to the control group.

3. Statistically, there was no difference in the height of the mandibular body between the two groups.

4. Statistically, there was no difference in the width of the mandibular ramus between the two groups.

5. Statistically, there was a decrease in molar distance of the experimental as compared to the control group.

6. Statistically, there was a decrease in the height of the mandibular ramus, as compared to the controls.

7. There was no shifting of the mid-line.

8. The control group did not present any apparent deformity in the mandibular ramus and body. Experimental group did not present any apparent deformity of the mandibular body but the condylar region presented some remarkable variations such as a) rough and ragged mandibular head and b) complete absence of the mandibular condyle.

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APPROVAL SHEET

The thesis submitted by Dr. V. M. Sanghani has been read and approved by three members of the Department of Oral Biology.

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 24, 1965

Date

Joseph M. Gengiel

Signature of Advisor