BAHAGIAN PENYELIDIKAN & PEMBANGUNAN
CANSELORI
UNIVERSITI SAINS MALAYSIA

Laporan Akhir Projek Penyelidikan Jangka Pendek

1) Nama Penyelidik

DR. SUZINA SHEIKH AB HAMID

Nama Penyelidik - Penyelidik Lain
(Jika Berkaitan)

PROF. AB. RANI SAMSUDIN

2) Pusat Pengajian/Pusat/Unit :

PUSAT PENGAJIAN SAINS PERUBATAN,
KAMPUS KESIHATAN,
UNIVERSITI SAINS MALAYSIA,
KUBANG KERIAN, KELANTAN

3) Tajuk Projek :

CRANIOFACIAL GROWTH CHANGES FOLLOWING SURGICALLY CREATED DEFECT ON THE TEMPORAL MANDIBULAR JOINT

4) (a) Penemuan Projek/Abstrak

(Perlu disediakan makluman diantara 100 - 200 perkataan didalam Bahasa Malaysia dan Bahasa Inggeris ini kemudiannya akan dimuatkan ke dalam Laporan Tahunan Bahagian Penyelidikan & Pembangunan sebagai satu cara untuk menyampaikan dapatan projek tuan/puan kepada Pihak Universiti).

Pertumbuhan mandibular (rahang bawah) bergantung kepada perkembangan normal sendi temporomandibular dan perubahan kepada perkembangan normal ini akan mengganggu dimensi pertumbuhan mandibal. Kajian ini melibatkan lima ekor monyet (*Macaca fascicularis*) berumur 6-18 bulan yang menjalani pembedahan kondilektomy mandibular di sebelah kiri. Pengukuran tisu otot muka, analisis radiograf kefalometrik lateral dan anteroposterior, mengukuran pembentukan lengkung gigi ("dental arch") dan pemerhatian atrisi dental dilakukan setiap bulan selama 4 bulan selepas pembedahan.

Kami dapati kondilektomi unilateral mengakibatkan pertumbuhan kraniofasial yang abnormal. Setelah dibedah kesemua monyet menunjukkan penurunan ketinggian ramus mandibular di sebelah yang dibedah (kiri) berbanding dengan di sebelah yang tidak dibedah. Ketinggian bahagian fasial bawah lebih terganggu berbanding ketinggian bahagian fasial atas dan tengah. Terdapat ketidak seimbangan pembentukan lengkung gigi atas dan bawah, dan mendapati tahap atrisi yang tinggi di sebelah yang tidak dibedah berbanding di sebelah yang dibedah di sepanjang tempoh pemerhatian.

Mandibular growth depends largely on normal development of the temporomandibular joint and any disturbance in its normal development will affect the growth in the dimension of the mandible. The study was based on five 6-18 months old monkeys (*Macaca fascicularis*) that underwent mandibular condylectomy on the left side. Soft tissue measurement, lateral cephalometric and anteroposterior radiograph analysis, arch form measurement and dental attrition observation were done every month postsurgery for 4 months.

We found that unilateral condylectomy had produced abnormal craniofacial growth. All animals showed reduced height of the ramus on the operated side (left) compared with the unoperated side after unilateral condylectomy. The measurement values for the lower facial height were most affected compared to the upper and mid facial height. In addition there was asymmetry in both the upper and lower arch form and a higher degree of attrition was noted on the unoperated side compared to the operated side over the period of observation.

(b) Senaraikan Kata Kunci yang digunakan di dalam abstrak :

Bahasa Malaysia	**Bahasa Inggeris**
Monyet	Monkey
Sendi temporomandibular	Temporomandibular joint
Pertumbuhan kraniofasial	Craniofacial growth

5) Output Dan Faedah Projek

(a) Penerbitan (termasuk laporan /Seminar)
(Sila nyatakan jenis, tajuk, pengarang, tahun terbitan dan dimana telah diterbit/ dibentangkan)

Poster presentation

A H Suzina, S A B Afifi, A R Samsudin. Experimental Pediatric Craniofacial Surgery in Macacca Fascicularis, 9th National Conference on Medical Sciences 22 –23/ 05/ 2004, Universiti Sains Malaysia, Kelantan.

(b) Faedah-faedah lain Seperti Perkembangan Produk, Prospek Komersialisasi Dan Pendaftaran Paten
(jika ada dan perlu, sila gunakan kertas berasingan)

Tiadà

(c) Latihan Gunatenaga Manusia

i) Pelajar Siswazah : Tiada
ii) Pelajar Prasiswazah: Tiada
iii) Lain-lain: Tiada

6) Peralatan Yang Telah Dibeli: Tiada

UNTUK KEGUNAAN JAWATANKUASA PENYELIDIKAN UNIVERSITI

PROFESSOR AB. RAN SAMSUDIN
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JABATAN BENDAHARI

KUMPULAN PENYELIDIKAN GERAN JANGKA PENDEK

PENYATA PERBELANJAAN SEHINGGA 31 DISEMBER 2004

Jumlah Geran		19,926.00	Ketua Projek	DR SUZINA BT SHEIKH ABDUL HAMID
Peruntukan 2001			Tajuk Projek	CRANIOFACIAL GROWTH CHANGES
(Tahun 1)	RM	19,926.00		FOLLOWING SURGICAL CREATED DEFECT ON THE
				TEMPORAL MANDIBULAR JOINT
Peruntukan 2002				
(Tahun 2)	RM	0.00		
Peruntukan 2003			Tempoh	
(Tahun 3)	RM	0.00		
			No.Akaun:	304/PPSG/6131193

Akaun	PTJ	Projek	Donor	Peruntukan Projek	Perbelanjaan Terkumpul sehingga Tahun lalu	Peruntukan Semasa	Tanggungan Semasa	Bayaran Tahun Semasa	Belanja Tahun Semasa	Baki Projek
11000	PPSG	6131193		2,100.00	-	2,100.00	-	-	-	2,100.00
14000	PPSG	6131193		-	59.27	(59.27)	-	-	-	(59.27)
15000	PPSG	6131193		-	-	-	-	-	-	-
21000	PPSG	6131193		1,576.00	7,113.44	(5,537.44)	-	205.00	205.00	(5,742.44)
22000	PPSG	6131193		-	-	-	-	500.00	500.00	(500.00)
23000	PPSG	6131193		300.00	10.00	290.00	-	-	-	290.00
24000	PPSG	6131193		-	600.00	(600.00)	-	-	-	(600.00)
25000	PPSG	6131193		-	-	-	-	-	-	-
26000	PPSG	6131193		300.00	410.00	(110.00)	-	-	-	(110.00)
27000	PPSG	6131193		6,350.00	6,003.45	346.55	-	2,488.74	2,488.74	(2,142.19)
28000	PPSG	6131193		-	-	-	-	-	-	-
29000	PPSG	6131193		300.00	2,444.05	(2,144.05)	-	-	-	(2,144.05)
35000	PPSG	6131193		9,000.00	-	9,000.00	-	-	-	9,000.00
				19,926.00	16,640.21	3,285.79	-	3,193.74	3,193.74	92.05

TITLE

Craniofacial Growth Changes Following Surgically Created Defect on the Temporal Mandibular Joint

SUMMARY

Mandibular growth depends largely on normal development of the temporomandibular joint and any disturbance in its normal development will affect the growth in the dimension of the mandible. The study was based on five 6-18 months old monkeys (*Macaca fascicularis*) that underwent mandibular condylectomy on the left side. Soft tissue measurement, lateral cephalometric and anteroposterior radiograph analysis, arch form measurement and dental attrition observation were done every month postsurgery for 4 months.

We found that unilateral condylectomy had produced abnormal craniofacial growth. All animals showed reduced height of the ramus on the operated side (left) compared with the unoperated side after unilateral condylectomy. The measurement values for the lower facial height were most affected compared to the upper and mid facial height. In addition there was asymmetry in both the upper and lower arch form and a higher degree of attrition was noted on the unoperated side compared to the operated side over the period of observation.

INTRODUCTION

Early craniofacial development pathway will generally affect the final general appearance of the face at the end of facial growth period. The growth of the face is a complex process involving many growth processes particularly in mandible, mid face and cranial base. These processes occur at the same time and the overall pattern of growth results from the interplay between them. They must all harmonized with each other if a normal facial pattern is to result and a small deviations from harmonious or interruption of the growth at any point will affect the development of other growth points thus resulting in dysmorphology of the craniofacial complex. Several studies have been carried out to determine the pattern, physics and kinetics of growth to assist in further understanding of craniofacial development for eventual use in craniofacial corrective surgery. Due to the small and infrequent number of craniofacial dysmorphology cases in human as well as the difficulty and ethics issues involved when studying human models, most of the studies were carried out using animal models whereby defects could be conveniently induced for research purpose and the result may be extrapolated to the human facial growth.

Mandibular growth depends largely on normal development of the temporomandibular joint (TMJ) and any disturbance in its normal development will affect the growth in the dimension of the mandible[1]. Due to interrelations in the various growth points, dysmorphology in the mandible will consequently create changes in the general development of the craniofacial complex.

Surgical resection of the mandibular condyle is occasionally indicated in children for trauma, tumour, ankylosis, arthritis or internal derangement of the TMJ[2-4] but the resultant condylar deficiency usually cause disturbance of the growth[5]. It was reported that the first condylectomy was done in 1856 for the treatment of arthritis of the TMJ[6]. However the consequences of the effect is unpredictable and alter with age[1], such as in the patient under age 12 years there will be some remodeling of the condylar head after unilateral condylectomy[7]. Several experimental studies on the regeneration of the condyle after surgical resection in growing and mature animals have been carried out in the past. It was reported that there is greater potential of regeneration in the young animal compared to the adult animal[1,18]. These have also shown that the condyle does partially reform but with some disturbance of growth[8]. The study on growing and adult monkey done by Poswillo showed that if condylectomy were performed during the growing age then the growth and development of the jaw will be disturbed. If the operation is done after the growing period then the growth disturbance will be minimal[9].

Experimental studies on the effect of condylectomy on craniofacial growth and specifically on the growth of the mandible have been studied extensively in the past[12-20]. The attempt was made to prove or disprove the regularatory role of the condylar cartilage in mandibular growth. Older concepts have described the condylar cartilage as the pacemaker and organizer of the mandibular growth[10,11] but nowadays the condylar cartilage is considered as a critical site that contribute to the overall mandibular growth and its function is to provide regional adaptive growth in response to orofacial

functional demands[12]. The study on rat also showed that the condyle contributes to the development of lower jaw but not the dominant element that control and direct the growth of the mandible[13,14]. The rat's condylectomized mandible continued to participate in the function of the mastication, deglutition and respiration throughout the growing period[14].

Any dysmorphology in the mandible will consequently create changes in the general development of the craniofacial complex. Soni have reported that after condylectomy, there were changes in the cranial bone complexes on the side that had been operated on. The zygomatic arch, glenoid fossa and postglenoid process were less developed on the operated side than the unoperated side[15].

Experimental studies to investigate the effect of unilateral condylectomy have been carried out on rat[13,14,16], rabbit[17], sheep[8], pig[15], lamb[18,19] and monkey[12,20]. A marked facial asymmetric was observed on the unilateral condylectomized animal[13]. On the operated side compared with the unoperated side, there were a lesser total facial height and a shorter ramus with extensive deficiency in the posterosuperior region[17]. The same findings reported include a vertically shortened and horizontally widened mandibular ramus, antegonial notching, a shallow glenoid fossa, an elongated coronoid process and a decrease in mandibular length on the operated side[12].

Besides that the entire mandible was noted to be directed toward the operated side at opening of the mouth, the anterior and molar (unoperated side) open bite and

hyperocclusion after the operation[20,21]. There was shift of the mandibular midline to the affected side[12,13]. The bite force of the opposite side after condylectomy is greater than that of the operated side[1]. Thus the degree of the tooth attrition on the unoperated side made progress with passage of time[20].

Deficiency or absence of the mandibular growth or mandibular overgrowth is not an uncommon condition. However the growth of the craniofacial region and dental occlusion following the unilateral condylectomy are not well studied. Therefore the purpose of the study was to investigate the growth of the craniofacial region and dental occlusion following the unilateral condylectomy in the growing juvenile *Macaca fascicularis*. The results of the study will provide better understanding of craniofacialdental development related to abnormal TMJ growth and extrapolating the observations to clinical practice. Through this study the experience of conducting the animal experimental surgery can be useful for future experimental design on animal model.

MATERIALS AND METHODS

The study was based on seven 6-18 months old monkeys (*Macaca fascicularis*). The animals had predominantly mixed dentitions with permanent first molar in occlusion. The estimated age was based on dental eruption. The monkeys were obtained from Institute of Medical Research.

Before the beginning of the experimental period the monkey were caged individually in animal house in Universiti Sains Malaysia (USM) for 7-10 days for observation of any sign of illness. Examination and tuberculin test were done preoperatively to make sure the monkeys are free of disease. Preoperatively the monkeys appeared to have symmetrical faces, normal occlusion and dentition. Their diet consisted of banana and papaya and they were provided with drinking water. One monkey was used as a control with no surgical intervention and six had unilateral mandibular condylectomy on left side and the mandible was left to function normally postoperative. Unfortunately during the course of research one monkey died intraoperatively due to uncontrolled bleeding.

Preoperatively the monkey that was selected for surgically created defect of (TMJ) was kept to fast for 12 hours before surgery. The monkey was anaesthetized by mean of intramuscular injection of Xylazine at dosage of 5mg/kg. The area of surgery was prepared. The hair around the left was shaved and surgical scrub was performed. The monkey's weight was recorded. The soft tissue landmarks were measured with a ruler (Figure 3.2). Lateral cephalogram was obtained with animal's mandible held in the centric occlusion by rubber band placed around the crown of the head and under the body of the mandible.

All the five left joints were operated on, the right joints being the controls. A 3-cm vertical preauricular incision was made through skin, subcutaneous tissue and TMJ capsule to expose the disc (Figure 1). The head and neck of the left mandible was

removed 1 cm long from the joint by using round and fissure bur. Great care was taken not to injure the surrounding anatomical parts. Debris was removed by irrigation with copious normal saline and suction. The joint capsule, fascia and skin were sutured in layers.

Postoperatively the monkeys were managed in the animal house recovery room in USM. They were given analgesia such as Temgesic (Buprenorphine) at a dose of 0.05mg/kg three times daily for about a week. For the first 2 weeks postoperation, the monkeys were served with the soft diet and slowly change to normal diet.

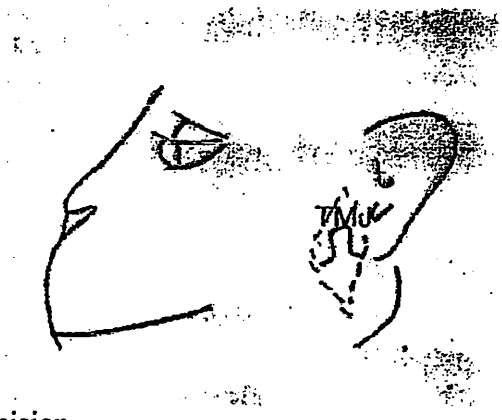


Figure 1. Preauricular Incision

Soft Tissue Measurement

A skin pen was used to mark the extra-oral anatomical landmarks (Figure 2). Easily accessible landmarks that maintain a very close and constant position to the underlying bone were chosen. Soft tissue measurements as shown in Figure 3 of the face of each operated monkey were done every month postsurgery for 4 months. The measurements were done by the same operator.

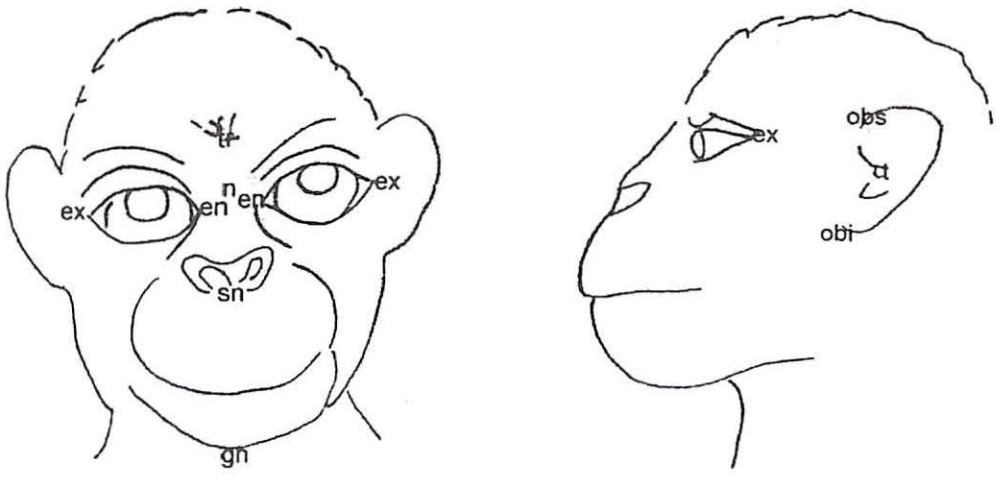


Figure 2. Soft Tissue Landmarks (Trichion (tr), Nasion (n), Subnasion (sn), Gnathion (gn), Endocanthion (en), Exocanthion (ex), Otobasion superius (obs), Otobasion inferius (obi), Tragion (t)).

Figure 3. Soft tissue measurement

Radiographic Method and Procedure

Standardized lateral cephalogram and anteroposterior radiograph (Figure 6 and 7) were taken at varying postsurgical intervals. The radiographic procedure was done under general anesthesia. The exposure was under SSKVP, 32mA and for 4.74ms. Standard Kodak films were used and were processed by developer with developing time and fixing time and air dried in 2 minutes. The lateral cephalometric and anteroposterior radiograph of each monkey were taken at a standard source-to-cassette holder distance of 100cm. All the radiographs were taken by the same operator. To prevent magnification error, the radiograph was standardized by means of a wire measuring 4cm placed directly on the film. The length of wire was measured on the exposed films area, so that any magnification in that area could be corrected and the linear measurements can be adjusted accordingly.

A tracing of each radiograph was made by using a 0.7 mm mechanical lead pencil. The error of the method was reduced by replicating and triple recording the 6 lateral and 6 anteroposterior radiographs.

Cephalometric Landmarks

The standardized radiographs were traced and the following landmarks were identified in each lateral cephalometric radiograph to be used in the analysis of the skeletal changes (Figure 4)[22,23].

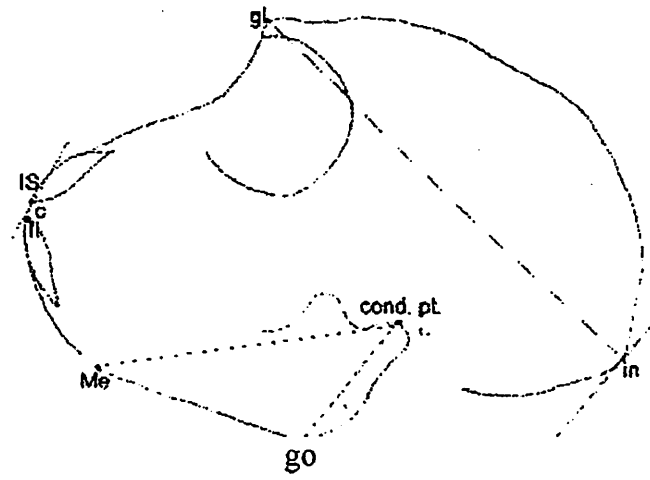


Figure 4. Lateral cephalometric analysis landmarks.

Lateral cephalometric analysis landmarks:

Glabella(gl) : most anterior point on the forehead.

Inion (in) : tip of the external occipital protuberance of the occipital bone

Condylar point (cond.pt.) : highest point on mandibular condyle

Menton (Me) : the lowermost point on the mandibular svmphysis

Gonion (go) : point of maximum curvature of mandibular angle

Incision superius (IS) : the tip of the crown of the most prominent mandibular Incisor

Incision inferius (II) : the tip of the crown of the most prominent maxillary incisor

Point C : midline between IS & II

Anteroposterior Radiograph

The standardized radiographs were traced and the following landmarks were identified in each radiograph to be used in the analysis of the skeletal changes. The unoperated side (right) served as control (Figure 5)[22,23].

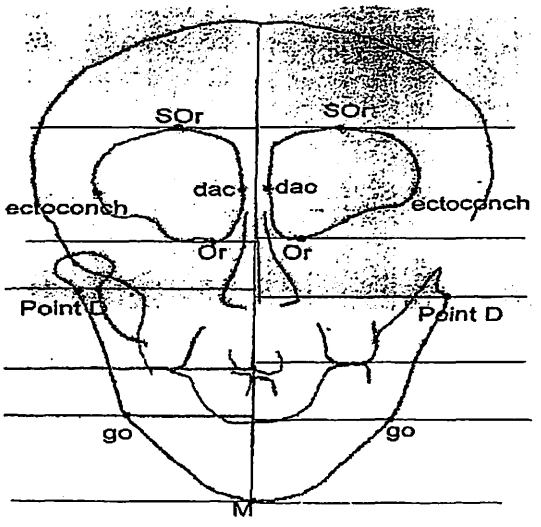


Figure 5. Anteroposterior radiograph tracing analysis

Anteroposterior (AP) radiograph tracing analysis landmarks:

Supraorbitale (SOr) : uppermost point on the upper margin of the bony orbit

Orbitale (Or) : lowest point on the lower margin of the bony orbit

Dacryon (dac) : point of meeting of lacrimal ethmoid and frontal bones, in the medial wall of orbit

Ectoconchion (ectoconch): point on lateral border of orbit marking maximum breath from dac

Point D : neck of the condyle

Gonion (go) : point of maximum curvature of mandibular angle

Menton(Me) : the lowermost point on the mandibular symphysis

Figure 6. The position of the monkey while taking anteroposterior radiograph. Note a 4cm wire on the left side of the monkey's head used to make measurement correction.

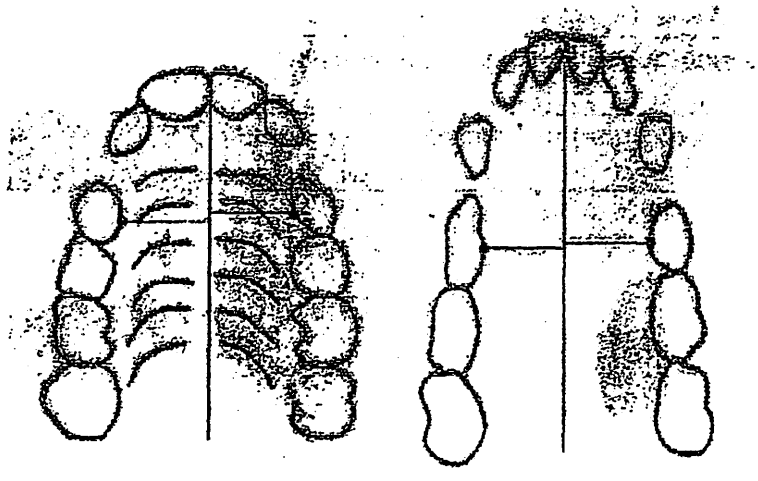
Figure 7. The position of the monkey while taking lateral cephalometric radiograph.

Dental Cast Model

Several perforated special tray made from acrylic resin were constructed to fix the dental arch of the monkey. Impression of the monkey was taken by using the alginate in the manual handling method. All the procedures were strictly followed according to the manufacturer's recommendation. All casts were poured within 3-5 minutes after the impression were made. This minimized the possibility of dimensional changes. In addition, a study has shown that measurements taken on the dental cast are directly comparable to measurements of the original teeth[24].

From the dental cast, measurements of the width of the dental arch were made between the bilateral teeth of the same tooth type, deciduous and permanent molar. For the upper arch, the rugae was used as the midline, while for the lower arch the frenum attach to the tongue was used as midline (Figure 8). The shortest distance on the lingual surface of the tooth was measured from the midline using the caliber.

All the measurements were repeat three times and the means of the results were used to do the comparison among the right (unoperated) side and left side of the arch.



Upper arch Lower arch

Figure 8. Arch form measurement

Clinical Observation of the Dental Attrition

Smith and knight tooth wear index were modified for measurement of the dental attrition in monkey (Table 1)[25]. This index required only a visual examination of the teeth under good illumination. All the examinations were done by the same examiner. Each surface of the tooth present was examined. The most attrited tooth surface was scored and represent that tooth. The degree of dental attrition in the right and the left arch was then compared with the passage of time. At the same time, any midline shift of the mandible was measured using the periodontal probe No 9.

Table I. Modification of the Smith and Knight tooth wear index

Score*	Criteria
0	No loss of surface characteristics
1	Loss of enamel surface characteristics
2	Loss of enamel exposing dentine for less than one third of the surface
3	Loss of enamel exposing dentine for more than one third of the surface
4	Complete loss of enamel, or pulp exposure, or exposure of the second dentine

* In case of doubt a lower score is given for the Exocanthion - Otobasion inferius (left and right) that exhibited the decreasing pattern 1 month later than the others.

RESULTS

The monkeys were examined daily in the early postsurgical period, then at weekly interval.

General observations

The five monkeys tolerated the surgical procedure well except for one monkey that died during the operation, The remaining monkeys recovered from anesthesia within four to six hours, then started drinking water and later progressed easily from a soft diet to a regular diet. There were no major infections or postoperative complications in any of the experimental animals. The monkeys were moving freely and swinging around their cages almost immediately after surgery.

Soft Tissue Measurement Analysis

The graphic analysis (Figure 9) showed that the growth of the upper facial height and the mid facial height was unaffected by the surgery. Compared to the upper facial area, there was initially a slower rate of growth at the mid facial area but the growth rate increased after 3 months into the postoperative period.

Serial measurements of the lower facial height showed a similar growth pattern, except for a decrease in vertical dimensions between the 3rd and 4th month postoperation.

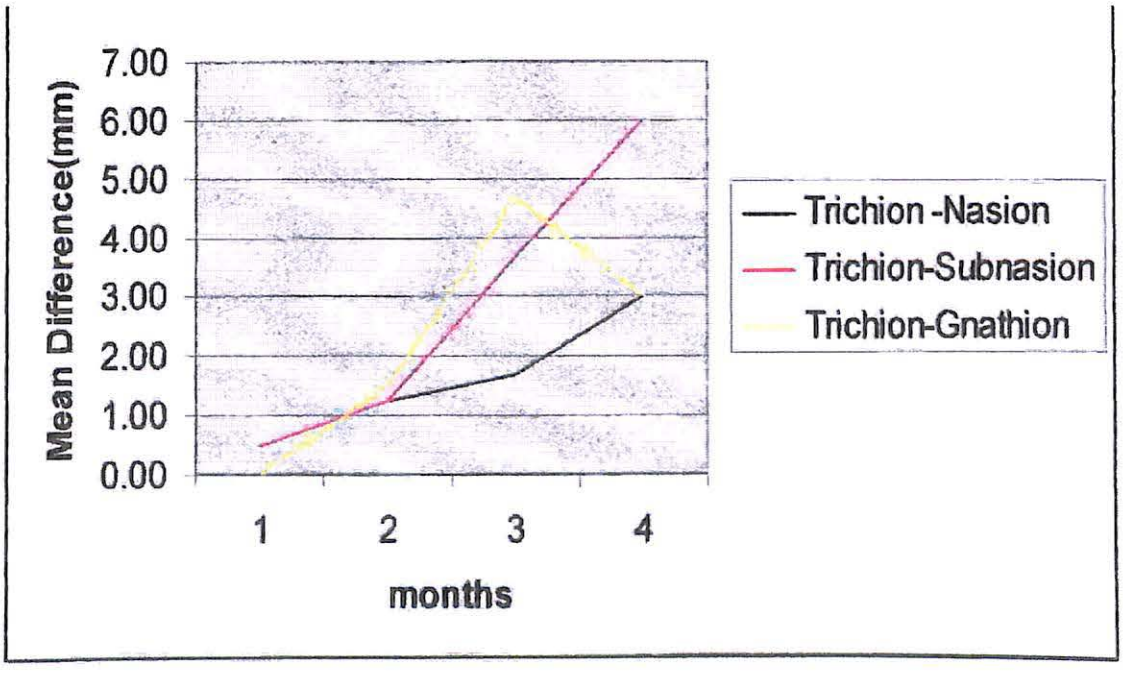


Figure 9. Vertical dimension of the soft tissue measurement (mean difference in mm) following unilateral (left) condylectomy *in Macaca fascicularis*.

Analysis of serial measurements of horizontal soft tissue dimensions (Figure 10) showed increasing pattern in facial growth but after two months postoperation the growth slowed

down. However all horizontal dimensions of the soft tissue measurements on the left side were marked reduced compared to the right side 4 months after left condylectomy.

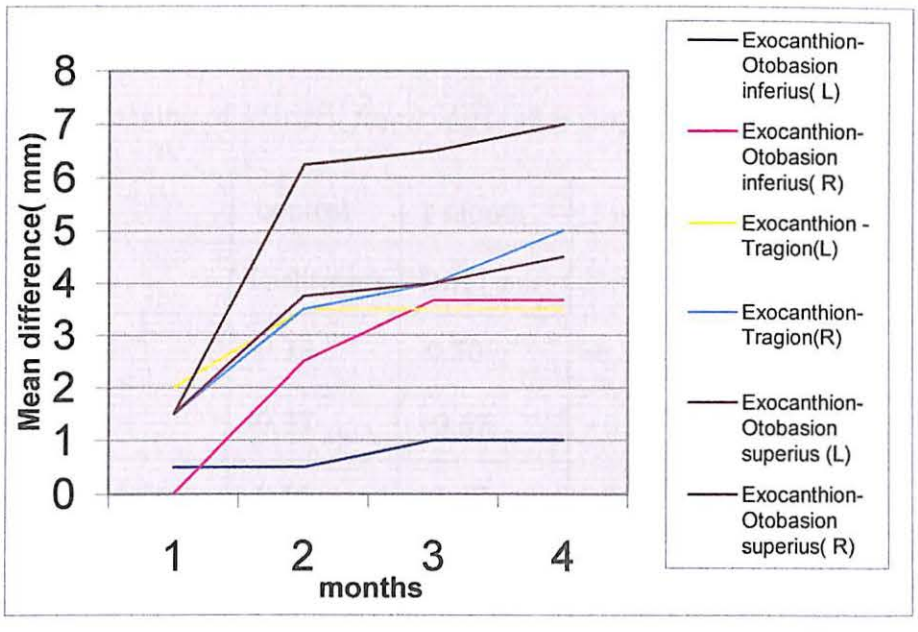


Figure 10. Horizontal dimension of the soft tissue measurement (mean difference in mm) following unilateral (left) condylectomy *in Macaca fascicularis.*

Anteriorposterior Radiographic Analysis

Generally there were no differences noted in the vertical dimension of the skeletal when comparing the right (unoperated) and the left (operated) side as shown in Table 2. The mean difference of the orbital height and lower mid face measurements were almost the same for the right and left sides. This is consistent with our study in soft tissue analysis which proposed that the upper facial height and the mid facial height is unaffected by surgery.

Horizontal dimension (dac-ectochonc) analysis showed the same results that there were no differences between the left and right side.

Table 2. Comparison study of the right (control) and left discrepancy from AP radiographic imaging of *Macaca fascicularis* after surgical created defect

	control	1 month	2 month	4 month
Variable	Diff.(mm)	Diff.(mm)	Diff.(mm)	Diff.(mm)
Orbital height	-0.33	-0.50	-0.33	+1.84
Lower mid face	-0.33	+0.67	+0.50	-0.50
Neck of condyle-go	-0.16	+1.67	+2.17	+3.17
Neck of condyle-Me	-0.33	+1.33	+2.34	+2.34
Dac-ectochonc	+0.66	-0.34	-0.50	+1.33

However the lower facial height exhibited some differences between the left and right sides. The right lower facial height seemed to be longer in skeletal analysis compared to the left side.

Arch Form Analysis

After unilateral left condylectomy, the upper arch of the monkeys showed some differences in measurements between the right and the left sides (Table 3). The left upper arch showed 1-2mm more in width compared to the right side. In contrary, the width of the right lower arch was wider than the left lower arch by 1-1.5mm (Table 4).

Table 3. Right (control) and left differences of the upper arch form following unilateral condylectomy (mm)

	control	1 month	2 months	3 months
Variable				
m_1- midline	0	-1.50	-0.50	-2.00
m_2- midline	-0.34	-1.83	-1.00	-2.33
M_1- midline	-0.17	-1.00	-0.50	-

Table 4. Right (control) and left differences of the lower arch form following unilateral condylectomy (mm)

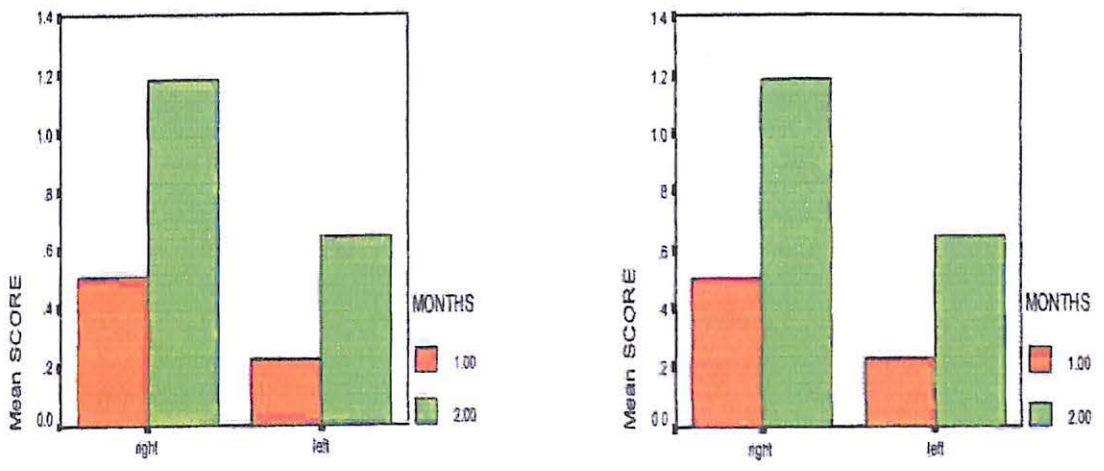
	control	1 month	2 months	3months
Variable				
m_1- midline	0	+1.67	+1.67	+1.00
m_2- midline	0	+1.50	+1.67	+1.00
M_1- midline	-0.17	+0.33	+1.33	-

m_1- deciduous molar 1, m2 - deciduous molar 2, M_1- permanent molar 1

Dental Attrition Analysis

Analysis of dental attrition following unilateral (left) condylectomy was carried out using the Modified Smith and Knight Tooth Wear Index. Statistical analysis as shown in the (Table 5) above revealed no differences of the level of attrition on the right and left side in monkeys after 1 months post op, for both upper and lower arches. In another set of monkeys that had undergone surgery, a similar pattern was noted after 2 months.

However based on my clinical observations of the monkeys post operatively, I noted there is more attrition in the right side compare to the left side.



a) Upper arch

b) Lower arch

Figure 11. Mean score of level of attrition in upper and lower arch following unilateral condylectomy

Table 5. Median score for the level of attrition following unilateral condylectomy

Post surgery	Right Median (IQR)	Left Median (IQR)
1 month	0 (0.1)	0 (0.0)
2 months	1 (0.2)	1 (0.1)

DISCUSSION

In our study, the juvenile monkeys (*Macaca Fasicularis*) were selected as the animal model based on the concept that human and nonhuman primates share the same physiological characteristics and similarities that arise through proximity on the evolutionary tree[26]. Initial preference of species has commonly been on the grounds that they are familiar animals about which much was already known, that they are convenient and safe to handle, that their nutritional needs and foibles are easy to meet, that they are tolerant to the physiological and psychological stresses inherent in captivity under restricted conditions, that they could be bred in the laboratory and that they are resistant to intercurrent disease.

The monkeys used in the experiment were between 6-18 months old. Monkeys under laboratory conditions can live to 15 years 5 months[27]. A monkey's age can also be assessed by the number of teeth present. For example, two permanent first molars = 17-20 months[28]. The monkeys used in this study are therefore equivalent to children aged around 2-6 years old. In this study the juvenile monkeys were selected as there is rapid growth during that period and therefore any abnormalities or facial dymorphology that might occur due to surgery would be detectable much earlier.

Sorenson and Laskins had suggested that the downward and forward movement of the mandible away from the cranial base is related to growth of its functional matrix and that contact with glenoid fossa is maintained by secondary growth of the condyle. The findings in this study support this concept. Loss or damage of the growing condyle limits

its role in maintaining ramus height and permits changes in the biomechanics of jaw function to produce alteration in mandibular morphology[29]. The findings of the present experiment also indicate that the absence of the condyle has a substantial effect on the amount of mandibular growth. Our results showed that after surgery there is still continuous growth of the upper facial height and the mid facial height. However the rate of growth in the first 3 month is slow most probably due to the disturbance created by the surgery. After 3 month the growth will be more rapid in the mid facial height than the upper facial height. This is because different parts of the craniofacial follow different growth patterns.

The lower facial height had somehow exhibited decreasing patterns between 3 and 4 months post operation. Similar findings were seen on analysis of the horizontal soft tissue dimensions. But the decreasing pattern was seen 1 month earlier than in the lower facial height measurements. These phenomena may have been due to soft tissue swelling which subsequently subsided and caused the measurements to be less than previously.

The skeletal analysis had shown similar findings that the upper facial height and mid facial height is unaffected by the surgery. But the ramus height of the mandible on the left side is shorter compare to the right. This indicates that after removal of the condyle, the height of the mandible will be largely affected but there is still a growth process going on. Therefore our findings support the theory that the condyle contributes to the development of the lower jaw but is not the dominant element that controls and directs the growth of the mandible[13-14]. The monkey's condylectomized mandibles continues to

participate in the functions of mastication, deglutition and respiration throughout the growing period. As the result of the findings of this study one can support the view that the growth of the lower jaw is affected to a certain extent by functional and environmental factors.

In the previous study, it showed that tooth position and dental arch form are closely related to the growth of the craniofacial complex[30]. The study, which looked at the width and length of the dental arch, had also been carried out according to chronological age[31]. It showed that the width of the dental arch would increase in the period of mixed dentition. Then it remained stable in the period of permanent dentition.

In our study, we are looking at the dental arch form and dental attrition following unilateral (left) condylectomy in juvenile monkeys (*Macaca fascicularis*). Our hypothesis was that after removal of the condyle, the arch form will be asymmetrical due to disturbance at the craniofacial complex. Normally the growth rate of the right and left side are the same. The findings from this experiment have shown a pronounced result that the right lower arch was wider compared to the left lower arch. This was because after the condylectomy the growth of the left mandible was largely affected by the surgery and became slower than the right side. This led to the wider arch form in the right compared to the left side. However in order to compensate for the asymmetry, compensatory mechanisms took place. The left side of the upper arch became wider than the right upper arch. Therefore we found that the left upper arch was wider than the right upper arch in order to achieve normal occlusion.

The study done by Miyamoto on sheep suggested that the bite force of the opposite side after condylectomy was greater than the operated side thus unilateral condylectomy resulted in lack of normal movement and increased load on the opposite side. From the histological findings there was evidence of more pronounced remodeling changes in the unoperated side[19]. The purpose of our study was to investigate generally how severe was the dental attrition following unilateral condylectomy. The severity of the level of attrition on the right and left side were studied as well. The findings of the present investigation did not show any difference in the tooth wear pattern statistically on comparing the right and left sides in the monkey. But there is more attrition noted on the right compare to the left side from clinical observation. This observation supports the previous study that the level of tooth attrition on the unoperated site was more severe than the left with passage of time.

There are some aspects of this study that necessitate further comments. The first extremely important fact that deserves further emphasis is that statistical analysis cannot be carried out due to the small number of monkeys that were available for this study. Secondly, we are lacking in knowledge regarding the exact anatomy of monkeys and are unsure regarding tracing the radiographic imaging of monkeys. Thirdly, when studying the dental attrition, the monkeys were in mixed dentition. This complicated the process of identifying certain teeth which had exfoliated. Fourthly, this experiment had been carried out in a short period whereas growth of the skull base as well as the mandible takes a long period to assess. Therefore, a longer duration of systematic study of the arch form

and the level of attrition should be carried out immediately after the eruption of the permanent dentition.

Extrapolating from these experimental observations to clinical practice, it is important to take early precaution and intervention to correct the asymmetry or abnormality following the unilateral condylectomy. Therefore our research gap is when and how to correct the abnormality surgically.

CONCLUSIONS

The study showed that unilateral condylectomy had produced abnormal growth. It has an impact on the craniofacial dysmophology. After unilateral condylectomy, the lower facial height is the most affected part compare to the upper and mid facial height.

All animals showed reduced height of the ramus on the operated side (left) compared with the unoperated side after unilateral condylectomy. The measurement values for the lower facial height is most affected compared to the upper and mid facial height. There was asymmetry in both the upper and lower arch form and a higher degree of attrition was noted on the unoperated side compared with operated side made over the period of observation.

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Laporan Akhir Projek Penyelidikan USM Jangka Pendek :
Tajuk Projek : **"Craniofacial Growth Changes Following Surgically Created Defect on the Temporal Mandibular Joint"** [No. Akaun : 304/PPSG/6131193]

Dengan segala hormatnya surat puan bertarikh 20 Mac 2005 tentang perkara di atas dirujuk.

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Saya yang menjalankan tugas,

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