

Kummoona Two Part Prosthesis for Replacement of the Temporomandibular Joint

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Abstract

Two-part chrome cobalt prosthesis designed to replace damaged temporomandibular joint (TMJ), experimental and clinical application of the prosthesis was done. The experimental studies were carried on *Macaca Iris Monkeys* by reconstruction of damaged TMJ, the lower part of the prosthesis was inserted and fixed in trough sagittal made by acrylic bone cement. After one-year animals were sacrificed and specimen was fixed and studied. Macroscopically, Microscopic, Radiologically and ground sections were done for studying the cellular changes about the implant and microradiography was done to demonstrate the location of the prosthesis in relation to glenoid fossa and ascending ramus of the mandible. This study proved the prosthesis was well tolerated by the tissue and biologically inert.

The prosthesis was applied on adult patients with ankylosed TMJ, where the growth of the face completed for restoration of function of the TMJ and to restore normal height and symmetry of the face.

Keywords: *Kummoona; Two Parts; Prosthesis; Chrome Cobalt; TMJ*

Introduction

In the mid seventy of the last century there was great demands for reconstruction or replacement of damaged temporomandibular joint (TMJ) by two part prosthesis due to difficulties we faced for replacement of damage joint with complete loss of function and growth due to condylar damages and fixation of the joint with callus formation on in the joint. Ankylosis either fibrous or bony structures or combined.

The technique been used before for management of ankylosed joint by excision of the ankylosed joint without filling the gap or filling the gap by muscles. All these procedures failed and ankylosis relapsed and squealed to chondrification or ossification of the muscle.

The success of John Charnley [2] in the early sixty of last century by advocation of his hip two-part metal prosthesis for management of cripple old patients suffering from TB and osteoarthritic damages of the hip joint make them unable to move or walk.

Sir John Charnley fixed the lower part of his prosthesis in the cancellous bone of the femur by using acrylic bone cement.

In the first 5 years of advocation of his prosthesis, few cases of Charnley prosthesis were reported that patients were complaining of pain in the joint from the two parts of hip prosthesis. Patients were complained and suffering from pain around the hip joint with loosening

of the prosthesis. This situation encourages Charnley to know and to find what is the cause for these symptoms.

By doing further research and he discovered the prosthesis he made was rubbing between the two parts of metals during walking by released metallic ions particles causing micro-thrombus blocking the small blood vessels supplying the area of the joint causing necrosis around the tissue of the prosthesis and failure of the prosthesis. He decided to change the cup in the acetabulum by Teflon to prevent rubbing of metals and releasing of ions.

The surgical option for reconstruction of the TMJ and the advances in facial-maxillary surgery during the last five decades represent an important challenge to maxillofacial surgeons.

There is always a therapeutic proposal had been put forward for tissue damages as result of disease or trauma to the anatomical structures of the TMJ.

In adult patient whose growth of the facial skeleton already completed, these people requiring two-part prosthesis to replace the ankylosed joint.

The ideal option is to use Kummoona two-part chrome cobalt prosthesis advocated 1975 and tested experimentally on Monkeys for restoration of normal masticatory process, normal excursion movement and facial height. The first primary report was published 1978.

The pioneer work of Sir John Charnley (1911 - 1982) in the beginning of the sixth decade of last century [2] by advocating his total hip replacement by two metallic prosthesis was great challenge to British Surgery and worldwide at that time to relief the suffering old people who became cripple by degenerative disease and TB of hip joint.

Ankylosis is the most severe insult to the human TMJ, a distressing disease effect child by traumatic injuries with damage to the joint structure and mandibular growth and function. Sometimes intrauterine injuries to the face and joint noticed during pregnancy. During delivery of the baby borne was noticed with ankylosis of TMJ.

Ankylosis means stiff joint with damaged condyle and callus formation featured either unilateral or bilateral types effect the growth of the mandible, maxilla and midface. Presented either fibrous or bony or mixture of bony and fibrous types. Ankyloses of the TMJ not only effect the growth of the midface and mandible but also damage the normal psychology of the patients.

In Iraq and worldwide in the seventies of the last century there was no solution to relief the suffering of young people complained from in ability to open their mouth in order to eat or swallow or even to sleep with respiratory apnoea. The author advocates his two-part chrome cobalt prosthesis as a pioneer work worldwide to solve and to make a solution to problems of this disease and to make relief the suffering of these people.

The mechanism of ankylosis occurred by trauma to the chin transmitted to the condyle along the long axis of the ascending ramus, the condyle in children is spongy and highly vascular. Hemarthrosis occurred associated with pain and swelling in the joint. The Child showed difficulty because of pain in opening and closing the mouth, this status lead to fibrosis and callus formation.

Ankylosis proceeded by effect of trauma with fragmentation of the meniscus and destruction and damages to cartilaginous part of the joint.

In the more severe injuries the impact not effecting the glenoid fossa only but extended to the petrous bone in the base of skull and severe bleeding might occur with rupture of tympanic membrane, bleeding come out from the ear it might be associated with CSF (Cerebro-Spinal Fluid), leakage (Otorrhea) and the case should be treated as head injury.

Clinical features of ankylosed TMJ showed under develop lower jaw, short ascending ramus with twisting of the chin to the effected side with under develop maxilla and midface with proclination of upper anterior teeth forward. The floor of the mouth was underdeveloped, the tongue in retro position with disturbance in anatomy of upper respiratory tract with hyperplasia of epiglottis and changes occurred in the pharyngeal-laryngeal inlet and formation of anti-gonial notch in the lower border of the mandible in the effected side.

This status makes the anaesthesia rather difficult in insertion of the tube for induction. The tube insertion either done blindly or by endoscopic guided tube with an expert anaesthetist without the need to tracheotomy.

Materials and Methods

We reported in 2009 seventy-six patients with ankylosis of the TMJ including 27 female and 49 males, their age ranged from 4 to 35 years (mean 19.5 year). Ten patients were treated by replacement of the TMJ by two parts chrome-cobalt prosthesis.

Design of the two-part chrome cobalt prosthesis

The author designed the prosthesis to replace the damaged TMJ of two parts chrome-cobalt prosthesis to satisfy the requirements of a functional demands of artificial joint, replacing both component of the TMJ.

The length of the lower prosthesis designed to be condylar head and neck representing one third of the total length of the lower prosthesis together with intra medullary perforated shaft or stem for transferring the load of the masticatory process to the mandible, the shaft represent two thirds of the total length of the lower prosthesis of about 4 - 5 cm length [1,2].

The arm or the shaft inserted sagittal in the cancellous bone of the ascending ramus through a trough made between the two cortical plate of the ascending ramus in the axial line. The managements were started by excision of damaged joint and hyperplastic coronoid with re attachment of masticatory muscles The shaft inserted in a trough made to accommodate the length of prosthesis shaft and fixed by bone cement (surgical autopolymerising bone cement containing methacrylate) to get the most intimate fit between the implant and the bone, the bone cement act as a cast. In animal experiment only the condyle was excised.

The cast function is to reduce the stress concentration and uniformly transferred the load of mastication through the long axis of the ramus from metallic shaft of the prosthesis to the cancellous bone of the ascending ramus which depend on bone elasticity, surface area, length of the shaft and the effect of lateral displacing force (excursion masticatory force).

The upper part designed to cover the glenoid fossa with arm or extension to cover the zygomatic root of temporal bone with two holes in the extension was made for fixation of the top part of the prosthesis by soft stainless-steel wire of 0.25 mm.

Experimental studies

In these experimental studies six adult *Macaca* Iris monkeys were used, aged 7 years and of the same weight. All of which undergone condylotomy and meniscectomy some three months previously, were divided into 3 groups of 2 animals each.

Surgical procedures were performed either under gas halothane anaesthesia or with Ketamine hydrochloride (Vetalar) sedation plus infiltration of a local analgesic agent in the TMJ area.

A precast chromium-cobalt alloy prosthesis was fixed in place after excision of the condyle and meniscus via pre auricular incision. The condylar part was fixed by using a surgical simplex bone cement (Howmedica Company, Dublin, Ireland) after a trough was made through the cancellous bone between the medial and lateral cortical plates of the ascending ramus along the long axis of the ramus. The trough size in animal was 1cm in length and 4 - 5 mm wide.

The upper prosthesis was fixed by 0.25 mm stainless steel wire. In the first groups the left side was replaced, in the second group the right side was replaced and in the last group both sides were replaced.

The animals were returned to normal cage life with a normal diet and antibiotic coverage with Triplopen every second day for one week.

Another experiment was done by excision of the condyle of the mandible of young Rabbits to observe the anatomical changes in the mandible and to prove the condyle carried primary growth centre.

Result of the Experiment

Neither masticatory function nor the ability to open or close the mouth was affected. All the animals remained in excellent health living in the colony for nearly one year.

One left, one right and one bilateral were considered successful. In other animals the condylar head and shaft were displaced but without effect on occlusion or mastication.

Radiographs were obtained routinely before and during the experiment at monthly interval till the animals were killed after one year. Normal occlusion was maintained and normal diet with no deviation of the lower jaw to operated side or open bite in the bilateral cases.

Post-mortem radiographic examination results showed the presence of an adequate functional joint after total replacement with the 2-part chrome cobalt prosthesis.

The changes that were occurred in Rabbits lower jaw after 3 months, we noticed severe deformity of the lower jaw, showed underdeveloped mandible in the affected side and the chin twisted to the effected side (Figure 1).



Figure 1: Right side condylotomy of young Rabbit, 3 months later showing severe deformity of the face and mandible.

Macroscopic, microscopic and micro radiographic examinations

Macroscopic observation to the post-mortem specimen showed a dense fibrous tissue with a smooth surface adjacent to the condylar head with a slippery oily feeling. The top prosthesis was covered by thin layer of fibrous tissue thinner than 0.5 mm. the metal was clean and smooth with no evidence or changes in the colour of the condylar head or corrosion or metal wear. The metal was also examined both optically and by scanning electron microscopy to exclude abrasion or metal on metal wear.

Between the two prosthesis there was a fibrous tissue layer of 2 mm in thickness, representing an articular disc. It seems this layer of tissue originated from capsular wall between the two metallic surfaces of the prosthesis and the outer cover of the prosthesis observed by the author by formation of thick fibrous tissue may represent the capsule of the joint, the medial part with smooth surface.

Microscopic examination showed the cellular changes observed around the bone cement and the condylar part. There were well organised granulation tissue and very well oriented collagen fibres with fibrous tissue beneath. The reaction to the metal and bone cement exceptionally good. The collagen fibres run parallel to the direction of the implant masticatory force and the bone in the surrounding area was vital.

The micro radiographic examination result of a thin histological section demonstrates the exact location of the implant and its relation to the surrounding tissue.

Our examination to the ground section, demonstrated tolerances of metallic joint and bone cement with incorporation of a healthy granulation tissue, collagen fibres and a new bone formation to justify the complete biological acceptance of the implant by the normal tissue [4] (Figure 2).

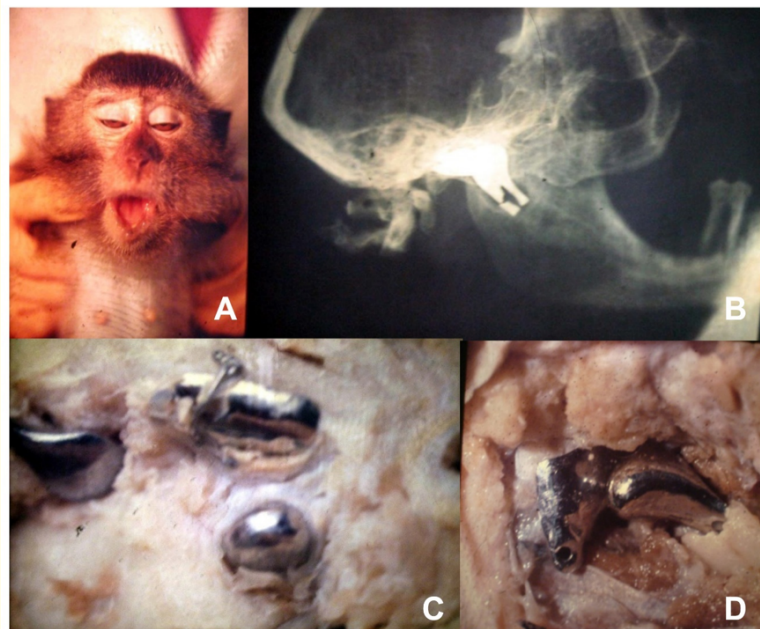


Figure 2: A: Photograph of Mecaca Iris Monkey, opening his mouth nicely one year post-operatively. B: X-ray of Post-mortem skull of Monkey showing the two-prosthesis cited nicely in their anatomical position. C: Exploration of TMJ specimen showing a band of fibrous tissue act as meniscus between the top and lower prosthesis. D: Clinical picture of TMJ Monkey after the joint replaced by two- part prosthesis.

Ground sections and microradiography

We did ground sections to the TMJ specimen demonstrated well tolerance of the metallic joints and bone cement after examination by making very thin histological sections and demonstrated the exact location of the implant and its relation to surrounding tissue by micro radiographic technique.

Our observation to ground sections demonstrated tolerance of metallic joints and bone cement with incorporation of a healthy granulation tissue, collagen fibres and a new bone formed to such an extent as to justify the complete biological acceptance of the prosthesis by the natural tissue.

Clinical studies and follow-up results

We reported only 10 patients were treated by this technique because of shortage of the prosthesis and difficulties in fabrication of the prosthesis in the local dental laboratories.

These patients include 5 males and 5 females and their ages ranged between 7 and 26 years (mean 16.5 years). All the patients after replacement of the TMJ by prosthesis showed full masticatory function and good mouth opening and closing with excellent range of movement, in one patients only top prosthesis was replaced but the patient showed limited protrusive movements and one patient after 3 years subjected to trauma that ended with displaced TMJ prosthesis, the implant was removed and replaced by Sialastic implant (Figure 3).

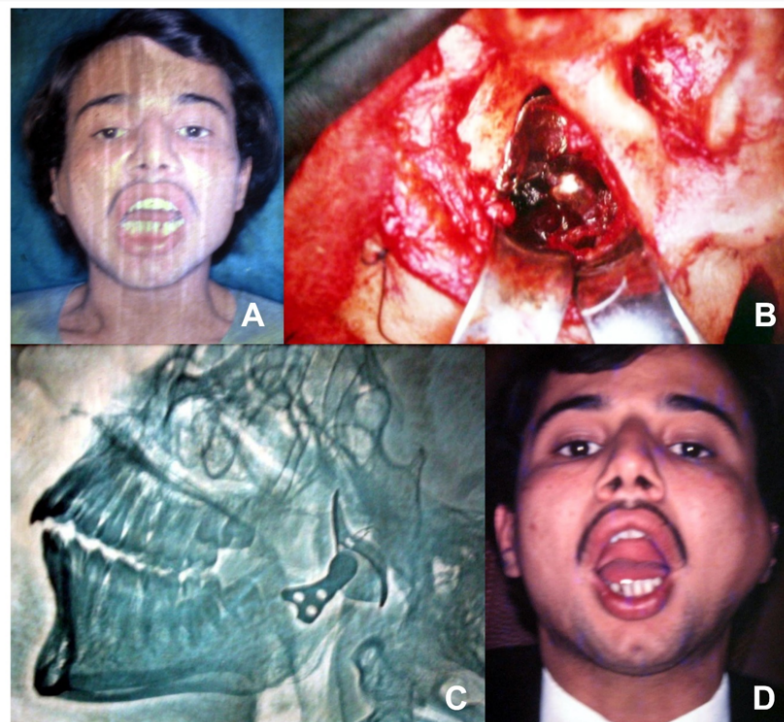


Figure 3: A: Young man of 20 years of age with TMJ ankylosis. B: Photograph showing clinically the two-part prosthesis replacing the TMJ after excision of ankylosed bone and hyperplastic coronoid. C: Xerography of the lateral skull showing the two- part prosthesis cited in good position. D: One-year post-operative photo showing excellent mouth opening and the patient in good health.

Flap design

Our flap deigned of full thickness as Fascio-cutaneous preauricular with temporal extension to behind temporalis muscle as? question mark shape technique.

The dissection of the flap started from behind the temporal part of the flap below temporal fascia down to the capsule of the joint. L shape incision was made in the capsule for exposing the ankylosed condyle and hyperplastic coronoid. Kummoona condylar retractor was inserted beneath the neck to protect the underlying tissue and maxillary artery from injuries (Figure 4).

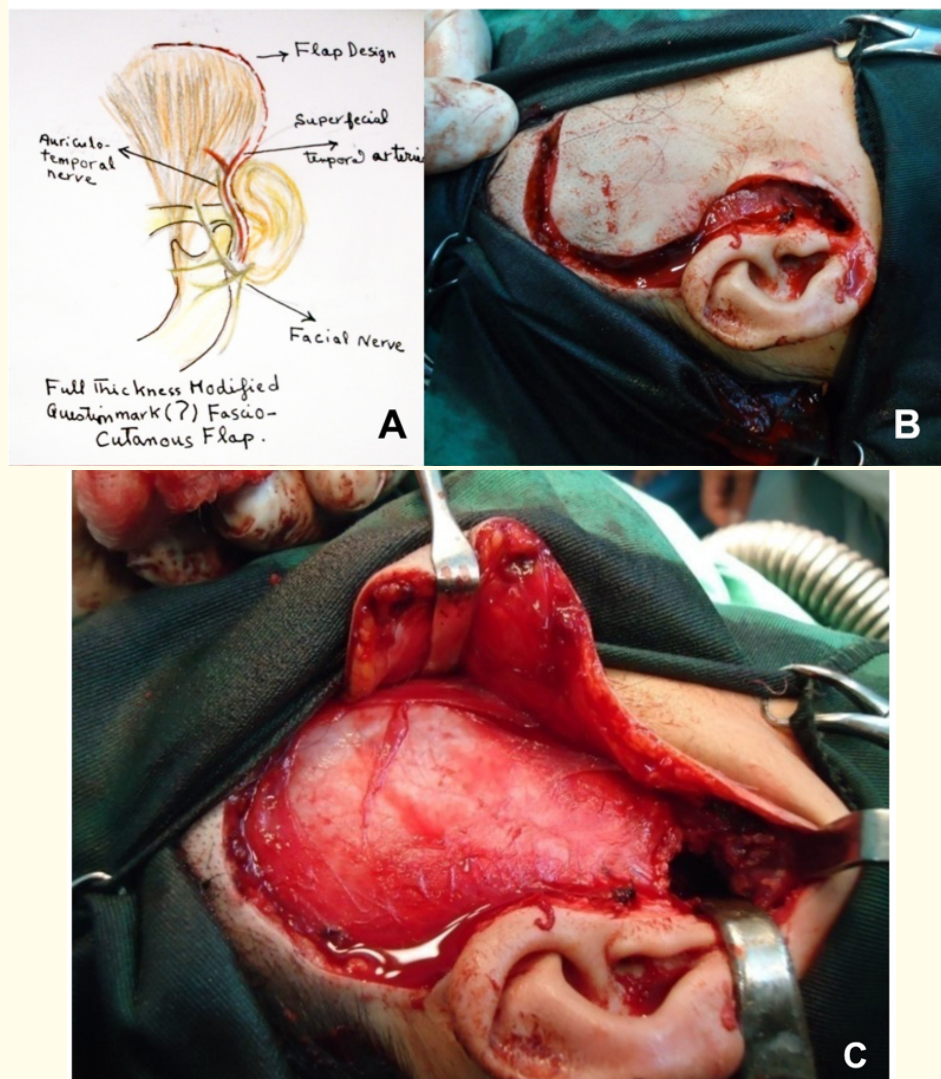


Figure 4: A: Diagram showing design of Kummoona Fascio-cutaneous flap from preauricular up extended to temporal region just behind temporalis muscle posterior fibres. B: Incision for Kummoona Fascio-Cutaneous Flap. C: Kummoona Fascio-cutaneous flap reflected down to the TMJ area and showing author special retractor inserted beneath the neck of the condyle to protect underlying structures and maxillary artery.

Two part prosthesis design for the TMJ

The chrome cobalt prosthesis consist from two parts, the top was designed to cover the glenoid fossa with an extension to zygomatic-root of temporal bone with two holes for fixation either by screw or by soft stainless steel wire of 0.25 mm.

The lower part consists of head representing the condyle and a shaft of about 4 - 5 cm of total length. The condyle length was designed to be one third of the total length, the shaft width about 1 and 1/2 cm to 2 cm the shaft designed to be perforated to let the bone cement to go in between the holes for anchoring. The shaft inserted sagittal in trough was made by fissure burs, filled by bone cement then the shaft of the lower prosthesis inserted in the trough and waiting for 8 minutes to set the bone cement (Figure 5).

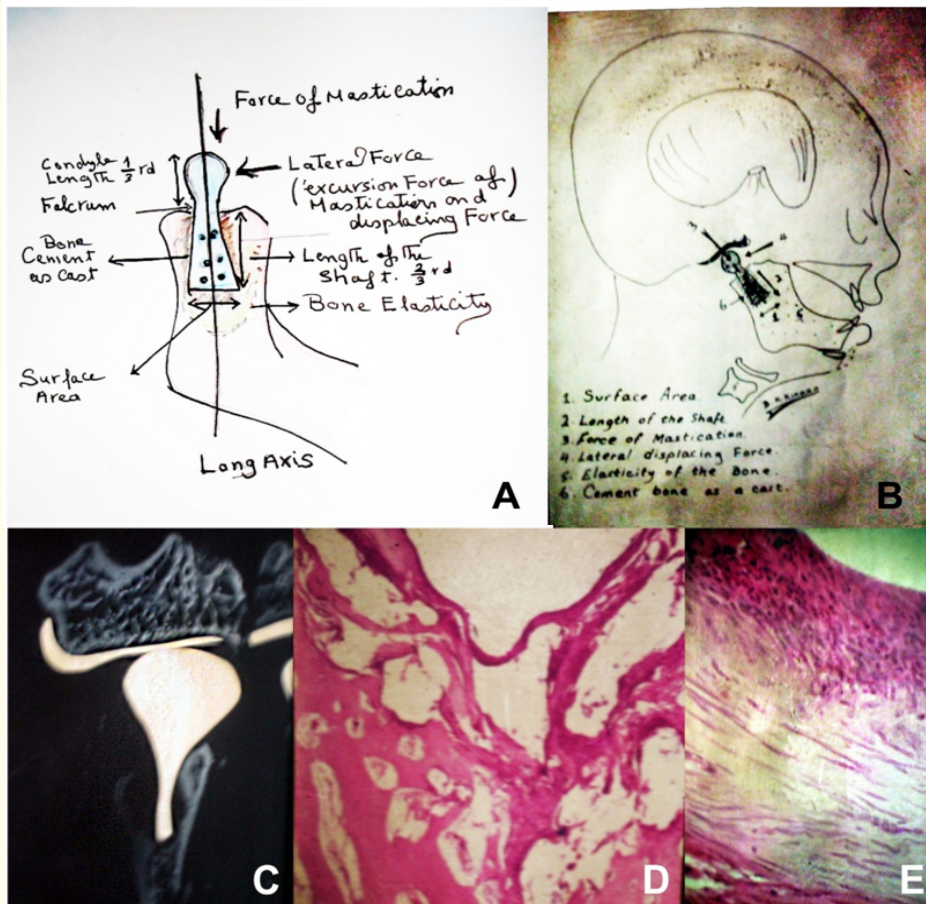


Figure 5: A: Diagram showing the design of the lower prosthesis which consist from condyle, neck and shaft, the shaft inserted in the trough made between the two cortical bone and fixed by bone cement and also showing the effect of masticatory forces and displacing forces. B: Diagram of the lateral face and the cite of two-part prosthesis in relation to long access of the ascending ramus. C: Microradiography of thin ground section showing the top prosthesis with no effect on glenoid fossa and healthy bone beneath and the lower prosthesis located nicely in the ramus in the long axis of the ramus. D: Histology of the ramus (H&E) of Monkey after removal of prosthesis and bone cement showing healthy granulation tissue with fibrous tissue surrounding the bone cement and shaft of the lower prosthesis. E: Histology of high power (H&E) showing healthy granulation tissue and fibrous tissue oriented in the same direction of masticatory forces.

The effect of masticatory force was transmitted vertically along the long access to the ascending ramus, the lateral force or excursion force, was considered as displacing force to the prosthesis. The lateral excursion masticatory force was overcome by length of the shaft about 2/3rd of the total length of the lower prosthesis and good fixation of the shaft by bone cement, while the condyle designed to be 1/3rd of the total length, the lower prosthesis was fixed by bone cement after filling the trough and the shaft inserted immediately before setting of the cement. The bone cement working as a cast and bone elasticity a cushion to absorb the lateral displacing excursion force and the surface area was also played a role.

The operation was mainly designed for adult patients with completion of the growth of the face. I have follow up one case for more than thirty years without any complications in range of movement or masticatory process or aesthetically.

Discussion

Two important point to be discussed, first biological inert of the metal are acceptable because the implant covered by thin layer of chromium oxide, this layer makes the prosthesis biologically inert.

The second point is the friction between the upper and lower parts of the prosthesis and lubrication of the joint. The friction between the two metals and releasing metallic ions particles to block the small blood vessels by making microthrombus supplying the area surrounding the prosthesis lead to necrosis of the surrounding tissue to end with failure of the prosthesis, this phenomena was noticed by Sir John Charnley prosthesis [2] in the first few cases done by Charnley.

We did overcome this phenomena by discovering through our animal experiment and dissection of the joint, there was a thin fibrous layer between the two parts of the prosthesis working as meniscus preventing the rubbing between the two parts of our prosthesis, and the presence of oily fluid most probably secreted from remnants of synovial fringes in the capsule working as lubricant agent.

The growth in adult already completed and damage to growth centre by ankylosis. Some Growth usually occurred after reconstruction of the joint by two-parts prosthesis the movements of the TMJ activate the muscles to grow by functional demands of the periosteal matrix according to Moss theory [4].

In children we need a growth centre [5] to replace the condyle and the ideal one and the most advance technique was by reconstruction of TMJ by Kummoona Chondro-Osseous Graft harvested from iliac crest for restoring growth, remodelling and repair of the condyle [6].

The long term performance of more than 30 years of the chrome cobalt prosthesis in our cases showed that, the prosthesis was well tolerated by surrounding tissues and no evidence of wear metals to cause osteolysis and formation of granulomatous sac as reported with other materials.

The advantages of Kummoona Two-Part Prosthesis were not only to restore normal masticatory process but also restoring a protrusive and lateral excursion movements while in reverse the other techniques disadvantages by replacing the TMJ by other synthetic materials to give only hinge movement but not restoring the all functional activities of the TMJ.

This study were supported by other researchers [1] they did retrieve the laboratory test results and the implants were examined both optically and by scanning electron microscopy testing the volumetric wear metal on metal of 20 magnitude less than that of acrylic on metal TMJ implants.

There are two theories dealing with growth of the face, the first one was John Hunter 1773 theory based on the condyle is a primary growth centre, this theory was well known and accepted by all the scientists and researchers till 1960 of the last century where Moss [4]

came with his new theory that the growth of the jaw occur due to functional demand of periosteal matrix of the facial skeleton and he think there was no primary growth centre in the condyle.

The author through his experimental studies on Rabbits after excision of Rabbit condyle, three months later we observed sever deformity of the lower jaw and the mandible was twisted to the affected side. This experiment was proved the condyle is a growth centre.

The author reached and believed there is no single theory dealing with growth of the face but both theories working to gathers in growth of the face.

Conclusion

In conclusion this research revealed to that, two-part chrome-cobalt prosthesis is an ideal solution for replacement of the TMJ in damaged joint specially in ankyloses of the joint when the growth of the face stopped in adult patient. The prosthesis is biologically inert due to presence of chromium oxide film covering around the prosthesis, experimental studies proved acceptance of the prosthesis by surrounding tissue and tested Macroscopically, Microscopically, ground section technique and micro radiographically.

It is an ideal technique for replacement of the TMJ ankylosis by this prosthesis for restoring mastication and certain amount of the growth of the face by activation of muscles of mastication and other muscles of the face for restoring normal height of the face and normal psychology of the patient.

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