

Cranial Bone Graft to Reconstruct the Mandibular Condyle Experimental Study

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1. Introduction

Reconstruction of the adult temporomandibular joint because congenital developmental, or acquired deformities continues to challenge the oral and maxillofacial surgeon.

A successfully reconstructed TMJ should reproduce normal joint structure, provide functional articulation, and permit adaptive growth or remodeling. Difficulty in achieving these treatment goals is illustrated by the multiplicity of autogenous, and allogenic materials proposed, or currently used to reconstruct the TMJ.

The major difficulties faced by the clinician are:

- 1) The unpredictable results after grafting procedures because of growth or resorption of transplanted autogenous graft resulting in mal-occlusion or facial asymmetry.
- 2) Jaw hypo-mobility caused by difficulty achieving early, vigorous physical therapy.
- 3) Complications; associated with alloplastic materials such as foreign body reaction, erosion of the glenoid fossa, decreased range of motion, and development of loose screws with subsequent loss of stability.

To address clinical TMJ reconstruction, we developed an animal model in which the mandibular condyle was reconstructed using a full-thickness cranial bone graft. The use of cranial bone graft for reconstruction of the condyle has not been described in the literature to our knowledge. Cranial bone grafts are commonly used for reconstruction of the facial skeleton in the form of onlay or interpositional grafts.

Clinical advantages of cranial bone grafts include decreased donor site-pain, minimal morbidity. The donor site is commonly in the same operative field. The graft consolidates and matures in a time frame comparable to that of rib or ileum, and it can be harvested with a straight or convex contour of importance for TMJ reconstruction. Cranial bone exhibits an increased volume of graft survival, with minimal resorption or remodeling of the graft when compared with ileum or rib.

In addition, cranial bone is more dense than other autologous grafts and may allow early functioning with a decreased risk of failure. Consequently, we hypothesized that use of cranial bone grafts may provide a more predictable result when used to reconstruct the condyle.

2. Aim of the Study

The aim of this study was to evaluate the efficacy of cranial bone grafts to reconstruct the mandibular condyle in a non

human model (in the rabbits).

3. Materials and Methods

This experimental study was carried out in the college of veterinary medicine, department of surgery.

Eight whitish rabbits were used as experimental animals, an average of 9 months age and weight of 2.5 - 3 kg.

Surgical instruments : which include scalpel (No. 15), blade, pair of the scissors (England), flap retractor (England), needle holder (England), artery forceps, towel clips, disposable syringe, surgical gloves, black silk (3.0) (Ethicon), portable hand piece with round and fissure burs, stain less steel wires cause 0.5 mm width.

Anaesthetic solution:

- 1) *Ketamin*: The drug is given either intramuscularly 30 mg/kg or no muscular relaxation. Rabbits will respond to visceral pain but not to superficial pain under the influence of ketamine. Ketamine frequently increases salivation. [Goth 1984]
- 2) *Xylazine (Rampone)* : The drug is given intramuscularly or intravenous routes. It induces a sedative hypnotic condition which is accompanied by a general muscle relaxation and insensibility to pain (analgesia-anesthesia). IM route: 6mg/kg IV route: 1.6 mg/kg
- 3) *Atropine*: are frequently given IM before anesthesia to decrease vascular cardiac tone and to block bronchial secretion. It is given intramuscularly (LML) [Goth 1984]

Surgical procedure:

The experimental animals have been weighed before and after operation and the body temperature for each animal was measured pre and post-operatively.

- 1) Anesthesia : by giving an IM injection of ketamine 30mg/kg and xylazine 6mg/kg. Atropine is used (one ml). Application of eye ointment to prevent dryness of the cornea.
- 2) Surgical operation: the surgical fields which are the periauricular and frontal areas were prepared for operation and shaved carefully, then sterilized by spirit and dettol.

A preauricular incision was done, the soft tissue with the muscles are retracted, the TMJ, then exposed. The condyle was resected by using the fissure bur after gentle dissection to the lateral pterygoid muscle, so that the maxillary artery was not traumatized otherwise, severe bleeding could occur. Care was also taken not to traumatize the auriculotemporal nerve, and facial nerve.

Thesecond operation was done at the same time by doing anincision in the frontal area, the frontal bone was exposed, a bout 5mmof the bone was removed by usmg the fissure bur with lowspeed and with cooling system to prevent damaging the osteo competent cells.

The cranial bone graft was put in the dish, which contain normal saline.

Then perforation was done in the cranial bone graft (two holes), and twoholes weredone in the ascending ramus by small round bur. Then, the wireswasinserted through the holes of the ascending ramus.Then insertedthe cranial bone graft through the twowires and then,tightfixationof the cranial bone graft to the ascending ramus. Suturing of .the both operative field after putting a topical antibiotic (powder of Ampicillin 250mg). Immediately, after operation, the animal were injected I.M with 250m of ampicillin vial as a single dose, then continue the ampicillin injection for the following three days after operation.

Post operativecare:

Few hours later, the animals were checked for recovery and checked its normal activities, normal mouth opening and returned to it's normal diet (vegetables and protein). Sutures were removed week posts operatively. ' Follow up:

The animals were allowed to resume cage activity post operatively. A specialground diet was provide in the first week. The animals were weighted weekly after the operation. Then, animals were Scarified by over dose of pentothal. The experimental animals are divided into three groups

- a) Scarified after 1.5 month by high dose of pentothal.
- b) Scarified after three months.
- c) Scarified after 8 months. Laboratory technique :

The cranial bone graft were then removed (with the areas of attachment with descending ramus), and placed in 10% neutral buffered formalin for seven days. Specimens were decalcified in decalcifying solution, and then transected into anterior, middle, and posterior portions approximately 1mm thick, they were embedded in paraffin, sectioned at 5-urn thicloless (three to six slices per block), stained with hematoxylin-eosin, and subjected to light microscopic examination.

The 10% neutral buffered formalin is prepared in two letters (formaldehyde 40% 200ml, sodium chloride 10g, sodium sulphate 30g, and distilled water 1800ml).

Tissues for light microscopical examination were fixed in 10% NBF for seven days. After trimming, they were subsequently post-fixed for two days in mercuric chloride formal. The fixatives were prepared as follows:
 tral buffered formalin:

Formal dehyde 40%.200ml	
Sodium chloride	10g
Sodium sulphate	50g
Distilled water	1800g

Mercuric chloride formal:

Saturated aqueous mercuric chloride	900ml
Formalin	100ml

After fixation, bones (cranial bone graft, ascending ramus, temporal bone) were decalcified, bones placed in decal solution formic acid, sodium citrate solution (Luna, 1966).

Tissues placed in decal solution must be washed in running tap water for a minimum of 24 hours before processing

Sodium citrate	
90% formic acid	25mg
Distilled water	75ml

Five ml formic acid-good routine decal fluid, minimum damage to tissue. With 5% formic acid, the decalcification will take approximately 2-4 days, depending upon the thickness of the block and degree of calcification.

After decalcification, tissues were dehydrated through ascending grades of alcohol, cleared in xylene and impregnated with paraffin wax.

Paraffin-embedded sections were cut at 5mg with a leitz rotary microtome and mounted on glass slides. Mounted sections were routinely stained with standard haematoxylin and eosin.

Slides were examined on a light microscope with photo automatic unit. [Luna 1966]



Figure 1: Instruments used in the procedure.



Figure 3: R: Ascending ramusC : Condyle



Figure 4: G: Cranial bone graft (6mm in length) C: Condyle (5 mm in length)



Figure 6: To see the two wires ligated the bone graft with the ascending ranius.

4. Results

Gross examination of the spacemen:



Figure 8: Total joint structure

P : to show the wire which Hgate the tow bones (cranial bone graft with the ascending ramus). This are a of healing after eight months.

5. Histologicalexamination

A. Stage No one: After 1.5 month.

The graft of this stage show more evident of connective tissue between the two ends of bonny fragment, and having highly precipitation of fibroblasts with collagen fibers and in

this area show vascularized patches well develop and infiltrate wide capillaries (sinusoid) and beginning development of periosteum and the starting of deposit of calcified material and with few osteoblasts. The strainghted muscle were present within grafting area under beginning of re attachment.

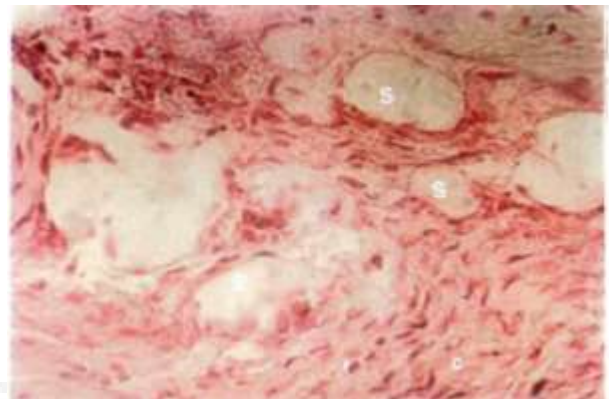


Figure 12: S: Sinusoids (wide Capillaries)
 f: Fibroblasts C: Collagen fibers

Hematoxin& Eosin Magnification x: 40

Stage No two: After three months. The connective tissue in this stage go many changes especially seen well develop, well connect the two fragments of the mature bones. Chondrocytes were present with in the cartilage (fig 13). This cartilaginous layer show different stages of calcification and ossification matrix. (Fig 13), Immature bone which show sharp irregular trabeculi.

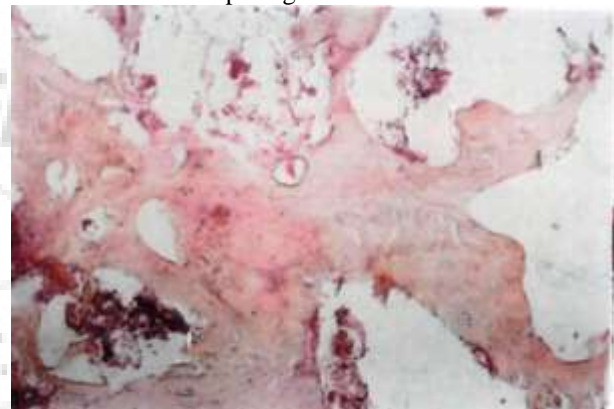


Figure 13: 1: To see irregular sharp bonny trabiteuli
 Hematoxin& Eosin Magnification X: 10

It appears that a condyle constructed with cranial bone provides a functional joint that is stable in terms of post operative resorption, and there fore produce a more stable, perdictable, result than joints reconstruct with costochondrai grafts which is done by perrot in 1990 on Monkey. Macintosh in 1992 found thati the rib grafts (on human) not only replace the condyle but also allow lengthening of the mandibular ramus. Guyuronin 1992 conclude that the growth of CCG (on human) is often unpredictable, and it is *non* comparable to the growth of the mandibular condyle. Poswillo in 1974 and Kaban in 1990 conclude that the CCG (ofhuman) grows mainly vertically, but to some extent also laterally, giving rise to an enlargement or bulging in front of the ear. The unpredictability of the costochondrai graft construct is readily acknowledged by most surgeons.

There is possibility of superior sagittal sinus laceration (in one of the animal), and this is one of complication of this procedure, but Tessier's land mark in 1982 reported describing autogenous calvarial bone grafts for facial reconstruction, he acknowledged the possibilities of csf or hemorrhage, but reported no complications in 234 grafts taken from 103 patients.

Also at the same time, Edwards and Qusterhout in 1987 reported that no morbidity or mortality in children with large or complex skull defects repaired with autogenic skull bone grafts, even though, they preferred to harvest the autogenous calvarial bone from over the superior sagittal sinus. Petroff in 1987 and Cinberg in 1985 have also described autogenous calvarial bone graft harvest with out any complication.

In reason of high resistance of our graft to resorption therefore, it provide a suitable alternative to other type of autogenous bone grafts for reconstruction of the condyle like the iliac bone especially the posterior crest rather than he anterior crest because the anterior crest although, it consider the most common site with the highest concentration of osteocompetent cells, but Hall MB in 1991 claim that the anterior iliac crest offers an in sufficient amounts of bone for maxillo-facial surgeons and for this reason advocate the posterior ilium as donor site. The posterior approach has the risk of instability of the sacroiliac joint, and the necessity of turning the patient during surgery, which is a well-known risk factor for line or tube displacement.

Walk GH Vande in 1986 reported that full-thickness grafting of iliac bone (in human) result in a large contour defects and risks the complication of abdominal hernia through the donor site. CowlySp in 1983 reported that the main disadvantage with iliac crest harvest (in human) was reported to be the discomfort that resulted in delayed ambulation and prolonged hospitalization. Moosa AR in 1991 reported that pelvise surgery as well as postoperative immobilization are accompanied by an increased risk of postoperative deep venous thrombosis. In recent years, cranial bone had been advocated as donor site preferable to the iliac crest (in human). Sadove AM in 1990 and Jackson IT in 1986 reported that several advantages had been noted and included: a non visible scar , no secondary deformity at the donor site, abundance of bone in children, little postoperative pain, resulting in shorter hospitalization. Donor site in the same operative field, Greater graft volume survival with membranous bone (cranial bone).

It appeared that the crania! bone might provide a suitable alternative to alloplastic bonegrafts for reconstruction of the mandibular condyle inthe non growing patient, alloplastic bone graft (silastic or proplast-Teflon) might cause erosion of the glenoid fossa, foreign body reaction and then development of loose wires or screws with subsequent loss of stability (Kent JN, 1983). Macintosh in 1989 reported the formation of extensive fibrosis with or with out heterotopic bone formation after total joint reconstruction of the TMJ.

In a recent study, Marciani et ai in 1996 also reported on the ability of autogenous pericranium muscle and cranial bone to restore form and function to the TMJ in a non-human

primate model. However, their surgical model was quite different from the model used in our study.

After resection the mandibular condyle, it was reconstructed by performing a vertical split osteotomy of the ramus and repositioning the proximal segment superiorly, so, it could function as a condyle. Adiscectomy was performed and the pericranium muscle graft sutured to the peripheral attachments of the original disc. But here, the cranial bone was used as an onlay graft to reconstruct the residua! defect at the mandibular angle, and was not used to replace the resected condyle.

Although, many of the considerations are the same for congenital and acquired problems, *it* must be kept in mind that in most acquired TMJ problems, the muscles, ligaments, and disc are present, where as in a congenitally missing joint these elements are rudimentary or missing. Soperforming the reconstructing by bone grafts may or may not give a satisfactory functional joint.

6. Conclusion

Reconstruction of the condyles of the rabbits with a full-thickness cranial bone grafts provided functional joint that resisted resorption, in addition more dense than other autologous bone grafts. Cranial bone mighttherefore provide a suitable alternative to other autologous bone grafts (likelibgraft and iliac bone graft) or alloplastic grafts materials (such as silastic) for reconstruction of the condyles in anon human models.

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