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"Greenstick Fracture Technique for Adaptation and Fixation of Costochondral Graft in TMJ Ankylosis- Original Study"

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I. Introduction

The major objectives of surgical treatment in patients with temporomandibular joint ankylosis are meticulous and radical removal of the ankylotic bone and, reconstruction and restoration of the physiologic functions of the lower jaw. A successful reconstructed temporomandibular joint should reproduce normal joint structure, provide functional articulation, and permit adaptive growth and remodeling. Difficulty in achieving the treatment goal is illustrated by the multiplicity of autologous and allogenic materials proposed or currently used to reconstruct temporomandibular joint.

In 1989, Mosby and Hiatt described a new technique to securely fix the graft and therefore the dimension of gap between the rib graft and the mandible minimized while pressing the graft against the mandibular surface. In our study, we had developed a variation of this method, which enables a precise adaptation of the rib graft to the mandible by green stick fracturing of the graft.

In our study, four cases of unilateral true ankylosis of the temporomandibular joint in patients who had reported to the Department of Oral and Maxillofacial Surgery at Tamil Nadu Government Dental College and Hospital, Chennai have been treated by this technique of green stick fracturing of the rib grafts for fixation and adaptation of the costochondral rib graft.

Aim of the study:

Four patients with unilateral temporomandibular joint ankylosis who reported to the department were selected for this prospective study.

The parameters for evaluation of patients included: active mouth opening, intra-operative complications, post-operative complications, post-operative adaptation of the rib graft to the ramus of the mandible, post-operative esthetic and functional improvement.

Materials and Methods:

This study conducted in the Department of Oral and Maxillofacial Surgery Tamil Nadu Government College and Hospital. The patient sample consisted of four cases (2 female and 2 male in the age group of 4-12 years) with unilateral temporomandibular joint ankylosis. A careful thorough examination was done; all investigations were recorded as needed.

Cases Description:

Case 1:

A male patient of 12 years reported with difficulty in mouth opening since birth. Shifting of the mandible towards right was noted. Occlusion was deranged. On palpation right condylar movements not felt. Provisionally the case was diagnosed as unilateral bony ankylosis of the right side TM joint. FIG 1FIG 1a

Case 2:
A male patient of 6 years reported with difficulty in mouth opining and inability to take food. Shifting of the mandible towards left was noted. Occlusion was deranged. Anti-gonial notching accentuated on left side and palpable. Provisionally the case was diagnosed as unilateral bony ankylosis of the left side TM joint. FIG 2FIG 2a

Case 3:
A 4 year female patient reported with inability to open mouth. Patient gave history of forceps delivery during labour hours and initially mouth opening was normal and gradually decreasing to the present level. Deviation of chin towards left side noted. Anti-gonial notching accentuated on left side and palpable. No history of ENT problems. Provisionally the case was diagnosed as unilateral bony ankylosis of the left side TM joint.FIG 3FIG 3a

Case 4:
A female patient of 9 years reported with inability to open the mouth for the past 4 years. Patient had a fall following which she developed inability to open the mouth. Deviation of chin towards right side noted. Anti-gonial notching accentuated and palpable on the right side. Provisionally the case was diagnosed as unilateral bony ankylosis of the right side TM joint.FIG 4FIG 4a

Pre-operative preparation:
Patients were assessed for fitness to undergo surgery under G.A. patients were prepared before surgery. Patients were given Ampicillin 500mg pre-operatively.

Surgical Technique:

All the cases in this study were operated upon under general anesthesia using nitrous oxide and halothane. Intubation was difficult due to restricted mouth opening. In two cases intubation was done through blind nasal technique and in two cases, retrograde intubation technique was used for naso endo tracheal tube intubation.

Operative Procedure:

Alkayat and Bramley modification of the preauricular approach with temporal extension:

The scalp was shaved. Surgical site was scrubbed with cetavlon/povidone iodine, prepared with sterile drapes. The external auditory meatus was occluded with cotton wool pledget to prevent entry of blood and subsequent coagulam in to the tympanum.

The incision line was mapped out with a Bonney's blue. It starts just within the hairline, about a pinna's length above the ear and curves backwards and downwards well behind the main branches of the temporal vessels to the uppermost skin attachment of the pinna. Following this anteriorly to tragus and then moving end aurally and finally out again to skin crease in front of the lobe of the ear and no further.

The local infiltration of 1:200000 adrenaline saline or lignocaine with adrenaline is done along the incision line.

Using a No.15 blade, incision is started at the temporal end and taken down to temporalis fascia. In developing the flap from above, it is absolutely essential that temporalis fascia is properly identified and that the superficial fascia and pre auricular fascia are lifted as part of the skin flap. At about 2 cm above the malar arch, flap development should stop. At this stage, the skin is dissected off the cartilage of the tragus and its continuation as the cartilage of the external auditory canal. Working close to the cartilaginous canal automatically defines an avascular plane between it and the glenoid lobe of the parotid, which is turned forwards and downwards. This dissection leads directly to the post-glenoid tubercle and is at the depth of the temporalis fascia reached in the upper part of the flap development.

The pocket between the lateral and medial layers of the temporalis fascia is now identified; fat globules can always be seen shining at the root of the malar arch, an incision running at 45 degrees upwards and forwards is made through the superficial layer of temporalis fascia. Once inside this pocket, the periosteum of the malar arch on its deeper surface is safely incised and raised as one flap with the outer layer of temporal fascia and superficial fascia containing the nerves.

When the full extent of the periosteal incision has been completed, the tissue lateral to the joint capsule and condylar neck was safely reflected. The bifurcation of the facial nerve is not nearer than 2.5 cm in an infero-posterior direction from the post-glenoid tubercle. Deep dissection was not extended below the inferior limit of the long auditory meatus.

The capsule was divided with an inverted 'L' shaped incision. Horizontal limp of the L incision is made at or below the lateral rim of the glenoid fossa. The horizontal incision is then joined by either an anterior or posterior extension. The posterior vertical incision carries the risk of severing the retrodiscal tissue. The anterior vertical incision should not be placed further anteriorly then the tubercle to avoid injury to the facial

nerve. The tissues were stripped away sub periosteally from the condylar neck, sigmoid notch and lateral aspect of the upper part of the ramus. A curved condylar retractor was inserted around the posteromedial aspect of the condylar neck to protect the maxillary artery, as it lies immediately medial to the joint.

A surgical tapering tissue bur was angulated downwards and forwards from the posterior aspect of the ankylosed joint, an upper cut and the approximate level of the fusion of the two bones was made. This cut was approximate level of the fusion of the two bones made. This cut was continued medially, but not completely dividing the tissue on the medial aspect. A second, lower cut was then made from the sigmoid notch obliquely downwards and backwards to the posterior limit of the condylar neck, to obtain a gap of about 1.5 cm. The medial tissue was then divided using small osteotome. The central bony mass was then levered out, detaching any remaining adhesions. Any bony spicule on either surface was smoothened. Then it was made sure that the mandible was totally free and adequate mouth opening is achieved.FIG 5a

Submandibular approach:

The skin incision is placed at least 2 cm below the mandible to avoid the mandibular branch of the facial nerve.FIG 5 If the cervical branch is also to be avoided the incision must be made at least 3cm below angle and further forwards at 4 cm below the body of the mandible in the region of the mandibular notch. A neck skin crease was selected; bearing these distances in mind, and marked with Bonney's blue. An incision was made through skin, fat, platysma and the outer layer of the deep cervical fascia. At this level the flap is developed carrying the facial nerve branches upwards. Anteriorly, the facial vessels are ligated. On identifying the angle and body of the mandible, the masseter and periosteum are incised at the lower border of the mandible and turned upwards with the parotid capsule.

This approach provides adequate access to the lateral aspect of the ramus and gap arthroplasty created site.

Donor site procedure and harvesting of autogenous costochondral rib graft:

The angle of Louis identifies the manubrio sterna junction and at the level of second rib. Ribs were counted up to 6^{th} rib. A sub mammary incision was marked out over the sixth rib on the right side chest. FIG 6 The incision was then made through skin, superficial fascia, pectoralis major and the external intercostal muscles. FIG 7 The periosteum over the 6^{th} costal rib was exposed and incised. The rib and about 10mm of its cartilage was uncovered beyond costochondral junction.FIG 8 Once the rib and its cartilage were clearly exposed with retractors in position FIG 9, the rib was carefully dissected from its bed.FIG 10 Great care is taken to avoid accidental perforation of pleura. After harvesting the rib, the surgical site was checked for pleural perforation by filling up with saline solution and observing for air bubbles, if any. After achieving adequate hemostasis, the wound was closed in layers with 3.0 catgut for subcutaneous layer and the skin with the 4.0 prolene sutures.FIG 11 The harvested rib was stored in the saline solution. Wound dressing was done.

Technique of fixation of the costochondral rib graft:

The harvested graft was measured and shaped for a correct adaptation. A four hole mini plate was fixed to the external cortex of the rib with two 4mm long 2mm diameter screws.FIG 12 Then with a 701 bur a slight osteotomy cut is made on the inner cortex opposite the mid line of the miniplate.FIG 13 Later a gentle backward bending of the rib graft is performed, until a green stick fracture is achieved in the outer rib cortex, providing a better contour of the rib graft convexity to the concave shape of the ramus of the mandible. Then the rib graft is placed in the recipient site through submandibular incision and gently contoured to the mandibular surface.FIG 14 The costochondral graft was securely fixed to one or both cortical layers of the ascending ramus of the mandible with 8mm long and 2mm diameter screws in the remaining holes of the miniplate. Finally both the 4mm long screws were removed and replaced by two other screws increasing the rigid fixation of the graft. The wound is then closed in a standard fashion once the drain is placed. The submandibular and pre auricular incisions closed in layer with 3.0 vicryl for subcutaneous and 4.0 prolene for skin after ensuring hemostasis.FIG 15 Wound dressing for submandibular and pre auricular region done and mastoid pressure bandage was given.

Observation and results:

The four cases selected for this study were post-operatively observed and followed for a minimum period of 1 year. Periodic radiographs were obtained. The parameters used for evaluation were: function, any post op complications if any and adaptation of the graft to the ramus of the mandible. TABLE 1

Mouth Opening:

The pre-operative mouth opening in the four patients were in the range of 3-5 mm, with 1 case having nil mouth opening.

Intra-operatively, after resection of the callus and reconstruction with costochondral graft, a mouth opening of 30-35 mm was obtained in all cases.FIG 16a FIG 16b

With active physiotherapy nearly all patients maintained their mouth opening and exhibited good range of mandibular movements. FIG 16 c At the last follow-up, all patients showed satisfactory functional results.FIG 16d

Complications:

There were no intra-operative or post-operative complications in our series that merit mention.

Transient pain and edema that usually accompanies all surgical procedures were observed. One case reported of pain and limited movement of the chest. However, this was transient nature. No infection, either of the donor site or recipient site was seen.

Adaptation of the graft:

The adaptation of the graft was good in all the patients without any gap in between the costochondral graft and the ramus of the mandible. PA view mandible confirmed this.FIG 17a FIG 17b

Discussion:

Temporomandibular joint ankylosis is a distressing affliction that denies the victim the benefit of normal diet, careers that require normal speech and causes severe facial disfigurement that aggravates psychological stress. It is a serious debilitating condition that a maxillofacial surgeon may come across. The condition occurs unilaterally and less commonly bilaterally.

Ankylosis is most commonly associated with trauma 31-98%[1], local or systemic infections 10-49% of systemic disease 10% systemic cause or temporomandibular joint ankylosis include ankylosing spondylitis, rheumatoid arthritis and psoriasis. Ankylosis of temporomandibular joint can occur at any age, but it is usually seen in the younger age group. Mofty reported 58% incidence in 1-10 years age group in a series[2] and Adekeye reported 65.5% incidence in the same age group patients[3]. In growing individuals, the option timing for surgical relief of ankylosis is still under debate.

In the field of Oral and Maxillofacial surgery, temporomandibular joint ankylosis is a difficult problem for management. Myriad of surgical technique added to the confusion, recent trend was more towards 3 forms of surgical management. They are condylectomy, gap arthroplasty, and interpositional arthroplasty.

Mere Gap arthroplasty for temporomandibular joint ankylosis resulted in progressive open bite, mandibular retrusion and class II malocclusion after condylectomy[4]

Experimental studies have shown that incidence of reankylosis is more in gap arthroplasty than when interposing a medium in interpositional arthroplasty[5]

Efforts in using alloplastic materials like gold foil, tantalum, stainless steel, vitalium and acrylic as interpositional medium yielded unsatisfactory results[6]. The possibilities of rejection of the foreign material and reankylosis were more with these materials. Hence attention was focused on using biological tissues as interpositional medium, like rib cartilage, iliac bone, fibula head, metatarsal bone, meta torsophalyngeal joint, clavicle, sternoclavicular joint, temporalis muscle and fascia[7,8,9,10]

Condylar reconstruction restored the altered biomechanics arising from condylectomy or gap arthroplasty[11]. The mandible is changed from a third order lever into a first order resulting in open bite in bilateral temporomandibular joint ankylosis and deviation of chin in unilateral temporomandibular joint ankylosis. Reconstruction of condyle restores the mandible as a third order lever[12].

In a child if the condyle was not replaced there was insufficient compensatory growth[13]. Since condyle is the most active growth centre of the mandible and the peacemaker and organizer of mandibular growth.

The use of costochondral graft for temporomandibular joint ankylosis has become the most widely used procedure following its utilization as an actively growing unit for replacing the lost condyle in children within the growing period[14]. The intrinsic growth potential in transplanted costochondral junction growth centre is seen and it provides a rational treatment in temporomandibular joint reconstruction where continued mandibular growth is desired[15].

Early correction of temporomandibular joint ankylosis with costochondral graft provides: an adaptive centre for potential future growth, a matrix to provide most symmetrical mandibular growth and function, more normal and symmetric facial contour, correction of mandibular retrognathia and lateronathia, improvement of physiologic outlook for the patient.

Therefore the rational for using the costochondral graft in the child is; to avoid reankylosis, to restore the altered biomechanics, to provide a graft with growth capacities similar to the normal mandibular condyle[16].

A stable fixation of graft with miniplates and even decreasing the very less chance of pseudoarthrosis or delayed healing by means of green stick fracturing of the graft and perfectly adapting to the contour of the recipient site(ramus of the mandible). By all these means the risk factors which normally occurs with fixation of the graft was overcome in this study.

II. Conclusion

Over time there has been a general consensus that treating ankylosis alone would not suffice the patient and had to be provided with a mandibular joint that remained fully functional and contributed substantially to the growth of the jaw. Costochondral graft fitted the bill.

The costochondral graft has been extensively researched upon and tried. It has its own advantages: it has the capacity to adapt itself to the temporomandibular joint histologically, morphologically and macroscopically. This study was undertaken to develop a new fixation technique in adapting the costochondral graft to the ramus of the mandible. The radiographical and the functional results obtained in study were satisfactory. However, a definite conclusion regarding the superiority of the fixation technique could not be arrived. Since the size of our sample is less and duration of follow up of our patients is short, it was felt that a long term follow up was essential to study the adaption and fixation of the graft.

This modified fixation technique by the green stick fracturing of the costochondral graft still accords the surgeon a valuable choice for reconstruction of the temporomandibular joint in growing patients without any complications like delaying in healing, pseudoarthrosis and loosening and fracturing of the graft.

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Legends:
Fig 1: Case 1 preoperative mouth opening
Fig 1a: Case 1 preoperative OPG
Fig 2: Case 2 preoperative mouth opening
Fig 2a: Case 2 preoperative OPG
Fig 3: Case 3 preoperative mouth opening
Fig 3a: Case 3 preoperative OPG
Fig 4: Case 4 preoperative mouth opening
Fig 4a: Case 4 preoperative OPG
Fig 5a:Intra-operative picture showing Gap Arthroplasty
Fig 5: Sub-mandibular approach showing the skin incision placed at least 2 cm below the mandible
Fig 6: A sub mammary incision was marked out over the sixth rib on the right side chest
Fig 7: The incision made through skin, superficial fascia, pectoralis major and the external intercostal muscles
Fig 8: The rib and about 10mm of its cartilage was uncovered beyond costochondral junction
Fig 9: The rib and its cartilage were clearly exposed with retractors
Fig 10: The rib was carefully dissected from its bed
Fig 11: The wound was closed in layers with 3.0 catgut for subcutaneous layer and the skin with the 4.0 prolene sutures
Fig 12: A four hole mini plate was fixed to the external cortex of the rib with two 4mm long 2mm diameter screws
Fig 13: With a 701 bur a slight osteotomy cut is made on the inner cortex opposite the mid line of the miniplate
Fig 14: The rib graft is placed in the recipient site through submandibular incision and gently contoured to the mandibular surface
Fig 15: The submandibular and pre auricular incisions closed in layer with 3.0 vicryl for subcutaneous and 4.0 prolene for skin after ensuring hemostasis

Fig 16a: Case 1 postoperative mouth opening
Fig 16b: Case 2 postoperative mouth opening
Fig 16c: Case 3 postoperative mouth opening
Fig 16d: Case 4 postoperative mouth opening
Fig 17a: Case 1 Postoperative PA view
Fig 17b: Case 2 Postoperative PA view

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