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Journal of Maxillofacial and Oral Surgery

Neocondyle distraction osteogenesis in the management of temporomandibular joint ankylosis: Report of five cases with review of literature.

--Manuscript Draft--

Manuscript Number:	MAOS-D-13-00001
Full Title:	Neocondyle distraction osteogenesis in the management of temporomandibular joint ankylosis: Report of five cases with review of literature.
Article Type:	Clinical Paper
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Abstract:	Introduction and objectives: Management of Temporomandibular joint (TMJ) ankylosis is a challenging and rather daunting task owing to complex abnormal anatomy and its sequel to craniofacial structures. Various autogenous grafts and alloplastic materials have been tried with variable success for creation of a near normal joint. In recent years, neocondyle distraction has added a new dimension to the management of TMJ ankylosis. The aim of this paper is to describe the role of neocondyle distraction in TMJ ankylosis. Methods: Neocondyle distraction was carried out in five patients following gap arthroplasty with sliced slivers of costochondral graft as interposition material. Results: All five patients reported with adequate mouth opening and functional jaw movements. The procedure was well tolerated by all the patients. None of the patients underwent reankylosis following neocondyle distraction. Conclusion: With proper surgical planning and distraction protocol, neocondyle distraction is an effective and safe technique for TMJ reconstruction and preventing reankylosis.

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Title page

Manuscript type: Original Research

TITLE- Neocondyle distraction osteogenesis in the management of temporomandibular joint ankylosis: report of five cases with review of literature

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Short (Running) Title: neocondyle distraction in TMJ ankylosis

ACKNOWLEDGEMENT

"The authors deny any conflicts of interest."

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Neocondyle distraction osteogenesis in the management of temporomandibular joint ankylosis: Report of five cases with review of literature

Abstract:

Introduction and objectives:

Management of Temporomandibular joint (TMJ) ankylosis is a challenging and rather daunting task owing to complex abnormal anatomy and its sequel to craniofacial structures. Various autogenous grafts and alloplastic materials have been tried with variable success for creation of a near normal joint. In recent years, neocondyle distraction has added a new dimension to the management of TMJ ankylosis. The aim of this paper is to describe the role of neocondyle distraction in TMJ ankylosis.

Methods: Neocondyle distraction was carried out in five patients following gap arthroplasty with sliced slivers of costochondral graft as interposition material.

Results: All five patients reported with adequate mouth opening and functional jaw movements. The procedure was well tolerated by all the patients. None of the patients underwent reankylosis following neocondyle distraction.

Conclusion: With proper surgical planning and distraction protocol, neocondyle distraction is an effective and safe technique for TMJ reconstruction and preventing reankylosis.

Keywords: Distraction Osteogenesis. Neocondyle Distraction. TMJ Ankylosis. TMJ Reconstruction.

Introduction:

Ankylosis of temporomandibular joint (TMJ) is a relatively debilitating condition resulting in restricted mouth opening, limited functional movements and severe facial asymmetry during the growth phase leading to difficulty in mastication, swallowing, speech, airway obstruction and poor oral hygiene. Surgical treatment should aim at restoring the normal joint function, correction of facial asymmetry and preventing re-ankylosis.

Reconstruction of TMJ after ankylosis release is rather a challenging task due to its unique anatomy and physiology. Autogenous costochondral graft is the method of choice for TMJ reconstruction. However, it involves exploration of the second surgical site and possible complications include surgical site infection, chances of graft failure and unpredictable growth of the graft [1]. Even with a cartilage or bone graft the

necessity for a dynamic material to act like meniscus is mandatory for better functional rehabilitation of the joint.

Alloplastic materials have been used in the reconstruction of ramus condyle unit with limited advantages, higher complications and failure rates [2]. Vertical sliding ramus osteotomies [3] and reconstruction with resected ankylotic mass [4] have been tried but no single method has produced uniformly successful and satisfactory results with long term evaluation.

In the recent years, Distraction osteogenesis has been successfully applied in reconstruction of the TMJ. This technique involves gradual advancement of surgically created transport segment from the ramus towards the articulating surface of the temporal bone. The gap created after distraction is gradually filled with bone, while the leading edge is covered with fibrocartilagenous cap acting as an articular disc of the joint [5-7].

Materials and method:

The objective of this prospective cohort study was to determine the role of distraction osteogenesis in TMJ reconstruction. Of all the patients who reported to our centre with TMJ ankylosis, five patients (4 males and 1 female in the age range of 19 years to 23 years, mean age 21.2) were enrolled in this study. All patients underwent gap arthroplasty with ipsilateral as well as contralateral coronoidectomy to achieve good mouth opening intraoperatively. 1mm thick sliced chondral cartilage slivers were placed (free floating) in the form of a rosette on the ramus stump as interposition material to prevent reankylosis. Patients were advised aggressive physiotherapy to improve mouth opening.

Once adequate mouth opening was persistent for the follow up period of one year, the patients were re-evaluated for neocondyle regeneration. Patients with maximal interincisal opening (MIO) of greater than 30mm, no signs of reankylosis clinically and radiographically and patients with adequate ramus size and shape as determined in computed tomogram scan and 3D reconstruction to allow proper placement and fixation of distractor device were included in the study. Exclusion criteria included potentially uncooperative patients who cannot comply with the distraction protocol, patients with systemic conditions which can significantly affect the bone physiology and outcome of distraction osteogenesis. An informed consent was obtained prior to surgical intervention and for enrolment in the clinical study.

Orthopantomogram and lateral cephalogram were obtained preoperatively and at periodic intervals of every three months post operatively for a follow up period of 2 years. Computed tomogram scans with 3-D reconstruction (Siemens, Germany) were taken prior to surgery and one year post distraction for surgical planning and post-operative assessment respectively. The follow up period ranged from 14 months to 30 months (mean follow up 20.8 months). The intraoral distractors (KLS Martin, Jacksonville, FL) were used in this study.

Surgical procedure:

The surgical procedure is performed under general anaesthesia with naso-endotracheal intubation. A small incision is placed in the submandibular region, 2cm below the lower border of the mandible. The dissection is carried out and lateral surface of ramus and angle of the mandible were exposed reflecting the periosteum over the bone. No periosteal stripping should be attempted on the medial side thereby, maintaining adequate amount of soft tissue attachment and blood supply to the distraction site over the medial surface.

Once the dissection is complete and superior border of ramus is visible, the markings are placed for a reverse L-shape osteotomy extending from the sigmoid notch to approximately 1 cm above the inferior border of the mandible, preserving the angle region. The vertical cut should be planned parallel to the vector so it can direct the transport disc towards glenoid fossa. The transport disc is created from the ramus by making osteotomy cuts over the markings. The superior surface of the disc is rounded to simulate the condylar surface.

The distractor device is then oriented parallel to the vertical cut. The holes for device fixation are placed without changing the position of the device. The distractor is then fixed with the screws of appropriate size (Fig. 1a). Once the distractor device is fixed, the osteotomy can be completed, mobilizing the transport segment completely. The distractor is activated for 1-2mm intraoperatively to confirm the unrestricted movement of the transport disc in planned direction. The activation arm can be brought out from separate stab incision if needed (Fig. 2). The incision is then closed in layers. Routine IV antibiotics and analgesics are administered post-operatively for three days followed by oral administration for next four days.

After five days of latency period, the distraction is initiated 1mm daily (0.5 mm in morning and 0.5mm in evening) till the transport disc achieves close contact with the articular surface of temporal bone (Fig. 1b). The distractor is left in the neutral position for a consolidation period of six to eight weeks. Once the mature bone formation is evident radiographically, the distractor can be removed under general anaesthesia. During the entire treatment phase, patients should be motivated for aggressive physiotherapy and active mouth opening exercises.

Results:

The technique was well tolerated by all the patients. All five cases reported with satisfactory maximal interincisal opening ranging from 30 to 35mm (mean- 33mm± 2mm) (Fig. 3, Table 1). None of our patients reported with chronic pain or surgical site infection during and after the distraction phase.

The occlusion in all the patients remained stable throughout the process, however, in two cases mild posterior open bite developed on the affected side during distraction period which was corrected during the consolidation phase. Mandibular movements determined post operatively revealed no near normal functional movements emphasising the successful outcome of the technique.

Radiographic examination confirmed effective movement of the transport disc towards glenoid fossa. During consolidation period, bone formation was seen in the regenerate chamber. Physiological remodelling of the leading edge was also evident on subsequent radiographs (Fig. 4 and 5).

After removal of the distractor device, no significant changes were observed at distraction site. Patient reported with good mouth opening and improved functional movements during subsequent visits. On CT scan examination, mature bone was evident in the distraction gap and the articulating surface of the neocondyle exhibited more smooth and convex shape, without any signs of reankylosis (Fig. 6a and b).

Discussion:

In the recent years, management of TMJ ankylosis has advanced tremendously. *Kaban et al* in 1990 proposed a protocol for systematic approach for management of TMJ ankylosis [8]. In 2009, this protocol was modified and distraction osteogenesis was added as an alternative modality to costochondral graft for condylar reconstruction [9]. The main objective in the management of TMJ ankylosis is not only to achieve normal mouth opening but also to restore the missing joint anatomy and functions along with prevention of reankylosis in long term. Various techniques for the treatment of TMJ ankylosis and reconstruction of condyle-ramus unit with autogenous grafts, alloplastic materials and bovine bone grafts have been described in literature [10].

Gillies in 1920 first reported the use of costochondral grafts in the reconstruction of temporomandibular joints. Various autogenous grafts such as metatarsal heads, fibula, iliac, coronoid process and sternoclavicular joint have been tried with success for reconstruction of ramus-condyle unit. Costochondral graft is the gold standard

modality, however like all autogenous grafts; it has disadvantages of second site morbidity, risk of infection, graft fracture, chances of reankylosis and unpredictable growth potential [11].

In order to eliminate the above mentioned issues, several alloplastic prosthesis have been developed which have gained considerable attention among maxillofacial surgeons. However, cost factor, higher chances of implant rejection due to foreign body reaction, hardware loosening and potential risk of resorption of glenoid surface leading to exposure of middle cranial fossa limit their routine use [1, 12, 13]. Vertical sliding ramus osteotomies have been used to reconstruct ramus-condyle unit but this method is only feasible when ramus has adequate shape and size to act as donor site. Further, interposition material to prevent reankylosis and bone graft may be needed to fill the bony defect created after superior repositioning of the segment [14, 15].

Distraction osteogenesis has long been recognized as an effective technique in correction of craniofacial deformities and continuity defects in maxillofacial region. Distraction osteogenesis (DO) is the process of generating new bone in a gap between two bone segments in response to the application of graduated tensile force across the bone gap [16]. *Stucki-Mc Cormick* first reported the technique of neocondyle reconstruction using transport distraction osteogenesis [5]. Since then, surgeons have tried this technique successfully with encouraging results in the reconstruction of ramus-condyle unit for various pathoses of temporomandibular joint [6, 7, 17-20].

Animal studies have demonstrated that biomechanical properties of neocondyle under functional loading are equivalent to the physiologic condyle. Histologic analysis have revealed distraction gap filled with collagen fibrous tissue in early stages which is gradually replaced by mature bone almost indistinguishable from the surrounding normal bone approximately after 24 weeks post distraction [21].

The main advantage of this technique is distraction histogenesis which refers to simultaneous elongation of soft tissues adjacent to distraction site along with hard tissue correction. The newly formed advancing front of the distraction fibrocartilageneous cap over the leading surface of transport segment can act as a pseudo disc thereby, facilitating movement of neocondyle over glenoid surface as well as preventing reankylosis [19].

Proper osteotomy cuts and distractor orientation is the key in success of neocondyle distraction and is often a difficult task due to absence of well-defined glenoid fossa and the amount of bone left after gap arthroplasty. The distraction vector should be aimed more posteriorly and maximum movement of the disc should be carried out superiorly towards glenoid surface without compressing the interposition material if present, in order to achieve maximum TMJ anatomy and vertical correction of the ramal deficiency.

The neocondyle distraction has obvious advantages over autogenous grafts. The neocondyle is formed through the process of distraction osteogenesis, thereby obviating need for graft and elimination of second surgical site. There is no need for intermaxillary fixation and hence, functional movements can be started immediately after surgery which can be encouraging to the patient. This also reduces the chance of reankylosis. One can restore the normal ramus height along with the correction of soft tissue deficiency making this technique more preferable over other conventional methods of reconstructing ramus condyle unit. Further, animal studies suggest that neocondyle reconstructed by means of transport distraction has the potential to grow under functional stimuli of the temporomandibular joint comparable to condyle ramus growth of the contralateral normal side [22]. Therefore, this technique can be a viable option for TMJ reconstruction in growing children where facial symmetry after growth phase is one of the major concerns.

However, there are few drawbacks to this technique. The duration of the treatment is prolonged; the device needs to be activated on a daily basis at the recommended rate and rhythm followed by the consolidation period for several weeks. Hence, patient compliance is imminent. Cost factor is also a concern in distraction procedure as it requires two surgeries; distractor devices and its components are expensive. Device failure, vector loss, loosening of the hardware, pre-mature consolidation and non-union of the transport segment are possible complications associated with this technique [18].

A latency period of 5–7 days after surgery is necessary to allow time for initial callus formation and healing of the soft tissues. Consolidation and quality of bone formation in the regenerate chamber is largely determined by the rate and rhythm of the distraction. Faster distraction rates in enchondral bone might result in local ischemia in the distraction gap and delayed ossification or pseudarthrosis, whereas slower distraction rates might lead to premature ossification and consolidation [23]. In our study, gradual distraction rate of 1mm per day has been found to yield adequate movement of the transport disc as well as timely consolidation of the regenerate chamber. The activation port site should be cleaned daily and antibiotic dressing should be placed to keep the site infection free. The patient should be encouraged for active mouth opening exercises immediately after surgery to initiate remodelling of the condylar surface under functional load and prevent reankylosis. The distractor removal is often more difficult than its placement due to superior positioning of the upper plate and sometimes bone or fibrous tissue covering the screws, one may find it difficult to remove with indirect access through existing submandibular scar. To overcome this problem, the distractor devices are available with the

detachable plate system (KLS Martin, Jacksonville, FL) in which the plates and fixation screws can be left behind after removing the body of the distractor (Fig. 7).

Recently, it has been suggested that the height of the reconstructed condyle is not stable and the mandible tends to be asymmetrical with age, mainly owing to compromised blood supply to the transport segment [17]. Hence, further evaluation and long term follow up of this technique is warranted.

In our cases, efforts have been made to create transport segment of adequate size and avoiding periosteal stripping on the medial side thereby preserving maximal blood supply to the transport disc. None of our patients reported back with reduction in mouth opening or signs of reankylosis. Functional movements have been satisfactory in all the patients after neocondyle distraction. No significant resorption or loss of vertical height of distracted segment has been observed in any case radiographically so far.

Role of interposition material in neocondyle reconstruction is questionable. Few authors believe that the newly formed fibrocartilagenous cap is a capable barrier in preventing reankylosis [6], while an interposition material such as temporalis muscle has been tried [17, 18]. In this study, we have used sliced costochondral graft as interposition material with comparable results and success.

Cartilage in our view is a good choice and the method for dynamic interposition. Insertion of thin slivers of autogenic cartilage into the gap created after resection of the ankylotic mass would cause their optimal distribution during function of the neocondyle and provides a thin but effective barrier against reankylosis. The dynamic nature of sliced cartilage slivers promotes smooth movement of neocondyle and inhibits fibrous reunion of neocondyle and glenoid surface.

Further, we have performed neocondyle reconstruction approximately one year after resection of ankylotic mass, interposition with costochondral graft with or without contralateral coronoidectomy. This protocol has helped us to achieve good mouth opening, assess patient compliance prior to distraction and better evaluation of functional movements in patients before and after condylar reconstruction. However, one can perform ankylosis release and neocondyle distraction simultaneously to avoid multiple surgeries and reduce overall treatment time period, cost and morbidity. Future studies should focus on the long term assessment of this technique, role of osteoconductive materials in early consolidation, use of multivector distractor devices in neocondyle regeneration and correction of facial asymmetry simultaneously.

In conclusion neocondyle distraction is a novel approach for reconstruction of ramus condyle unit, thereby, restoring physiological temporomandibular joint function, simultaneously correcting hard and soft tissue

deficiency and preventing reankylosis. With proper technique and patient compliance, it is safe, predictable and effective procedure for temporomandibular joint reconstruction.

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Table:

Table1:

Patient	Age/Sex	Side	Total distraction	Follow up period	Preoperative mouth opening*	Postoperative mouth opening#
Case 1	23y/M	Right	11mm	30 months	32mm	35mm
Case 2	20y/M	Left	13mm	23months	30mm	34mm
Case 3	24y/M	Right	14mm	21 months	31mm	32mm
Case 4	20y/M	Right	11mm	18months	30mm	33mm
Case 5	19y/F	Right	10mm	14 months	35mm	35mm

Table Legend:

Table 1- Patient details, distraction height, preoperative and postoperative mouth opening.

*** Maximal interincisal opening 1 year after ankylosis release and prior to neocondyle distraction**

 # Maximal interincisal opening 1 year after neocondyle distraction

Figure legends:

Figure 1 (A)- Illustration showing suggested osteotomy markings and device orientation on 3D CT reconstruction image (B) The distraction gap is filled with bone while the leading edge undergoes remodelling and covered by fibrocartilagenous cap (Distractor image courtesy KLS Martin)

Figure 2- Distractor fixed across the segments. The activation arm is brought out through separate stab incision.

Figure 3 (A) - Pre-operative OPG of the patient after ankylosis release on right side. (B) Post-distraction OPG showing superior movement of transport disc towards glenoid surface.

Figure 4- Patient with right side TMJ ankylosis (A) before ankylosis release (MIO-10mm). (B) 1 year after interpositional gap arthroplasty (MIO-33mm). (C) 1 year after neocondyle distraction (MIO-35mm).

Figure 5- Six months post distraction OPG view showing position of transport segment to the glenoid surface and bone formation in regenerate chamber.

Figure 6- (A) Pre-operative and (B) 12 months post distraction CT scan (coronal section) showing neocondyle with mature bone formation in distraction gap.

Figure 7- KLS Martin ramus transport distractor with detachable attachments and retention plate for consolidation period specially developed for reconstructing hypoplastic ramus and temporomandibular joint.

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Fig. 1
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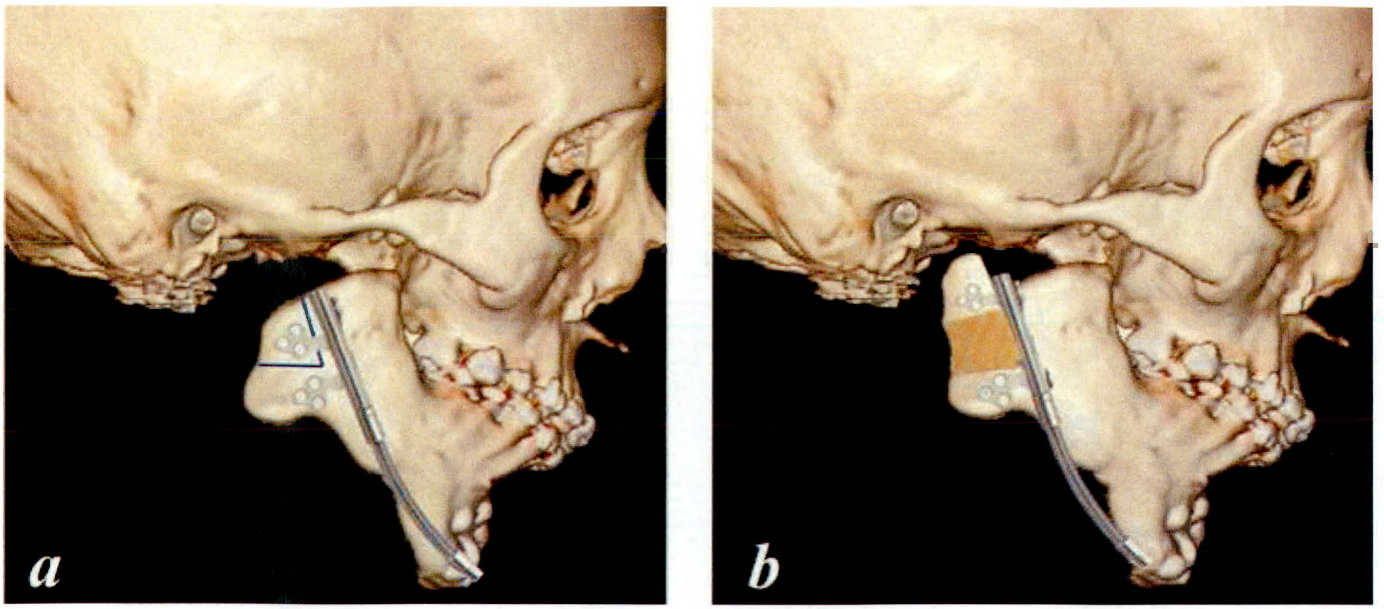


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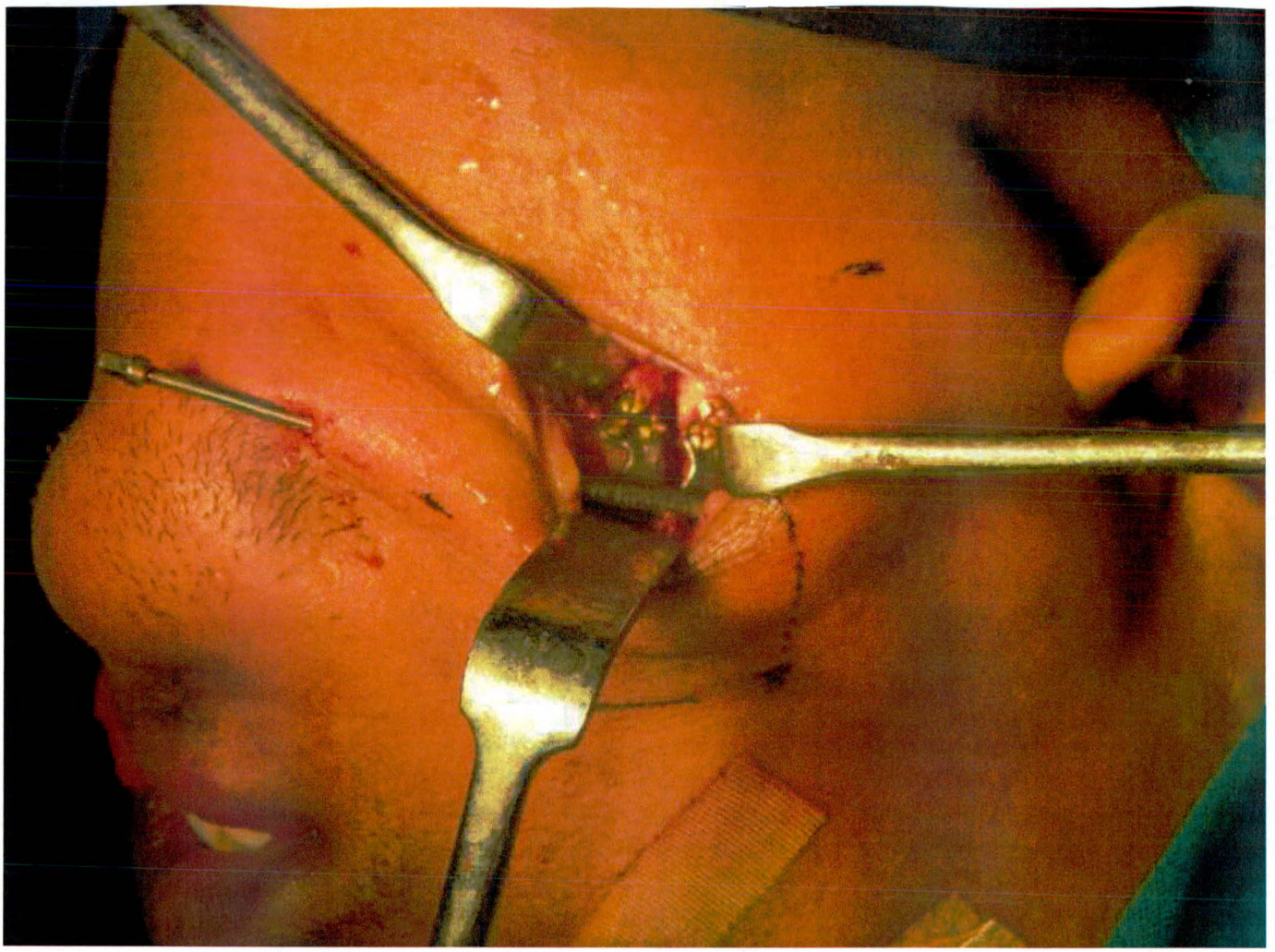


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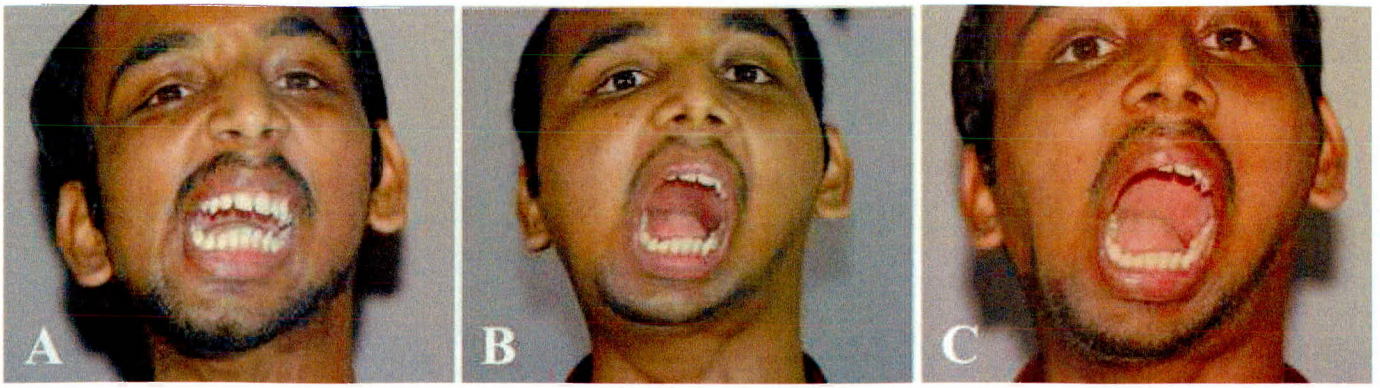


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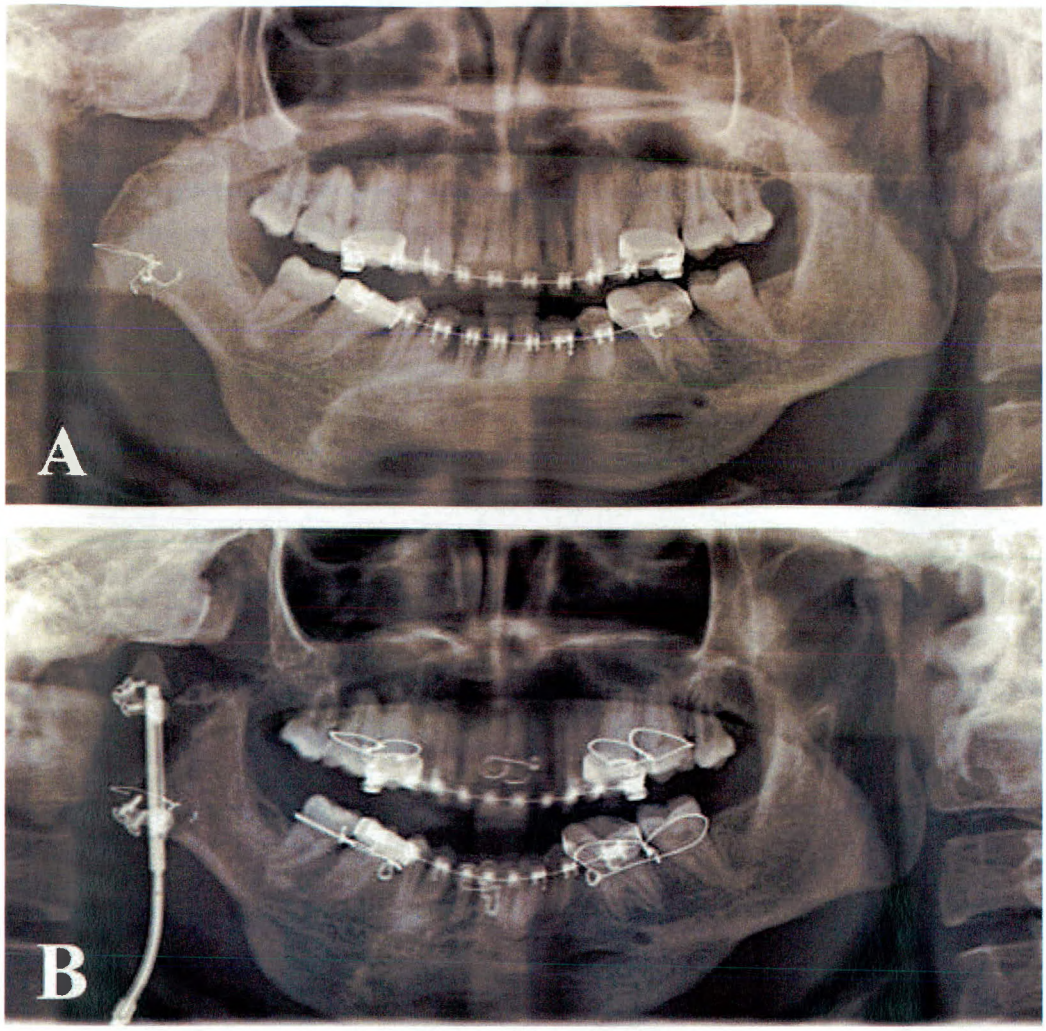


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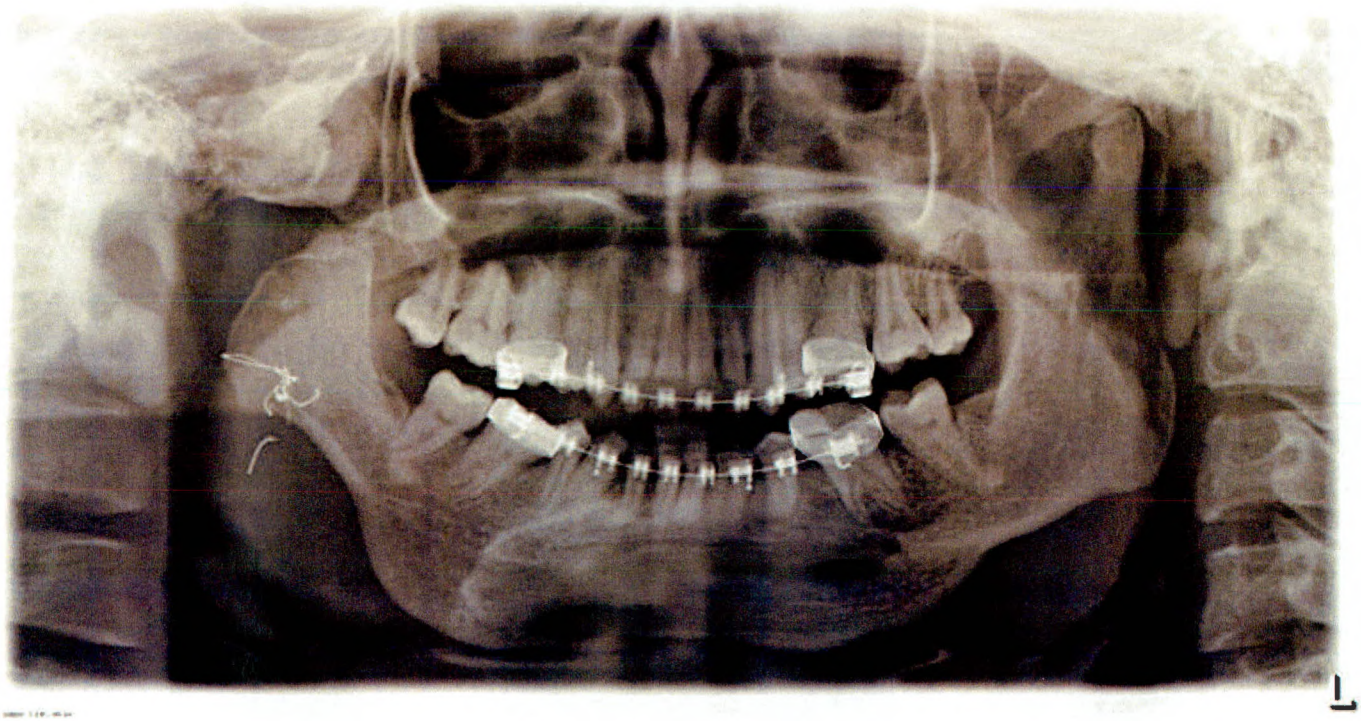


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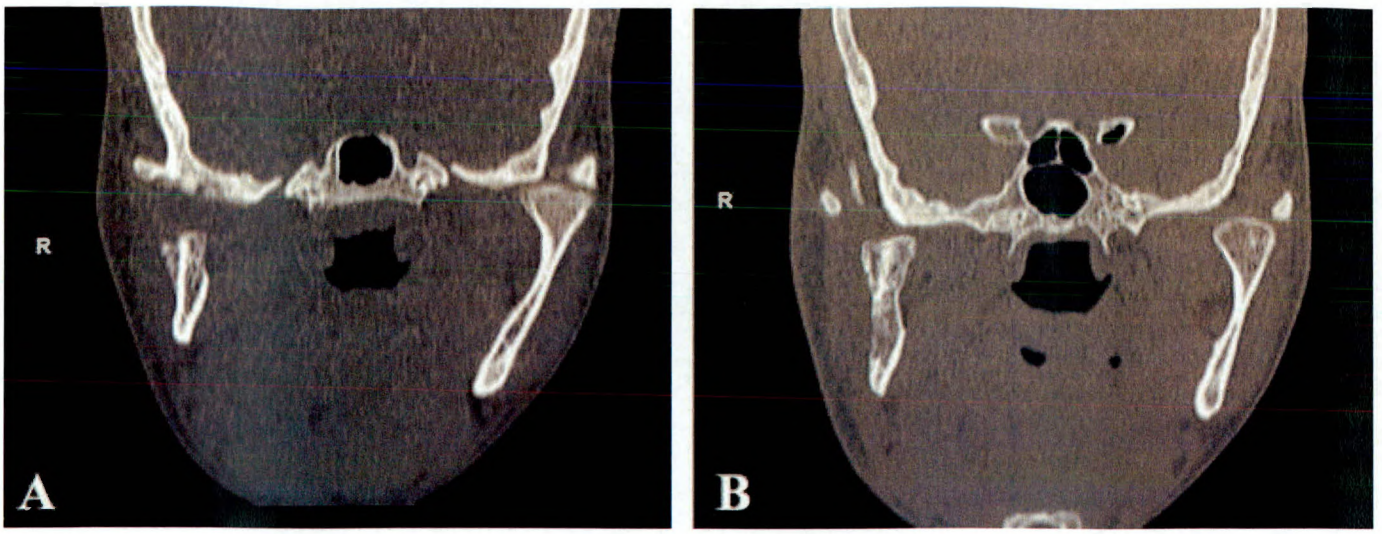
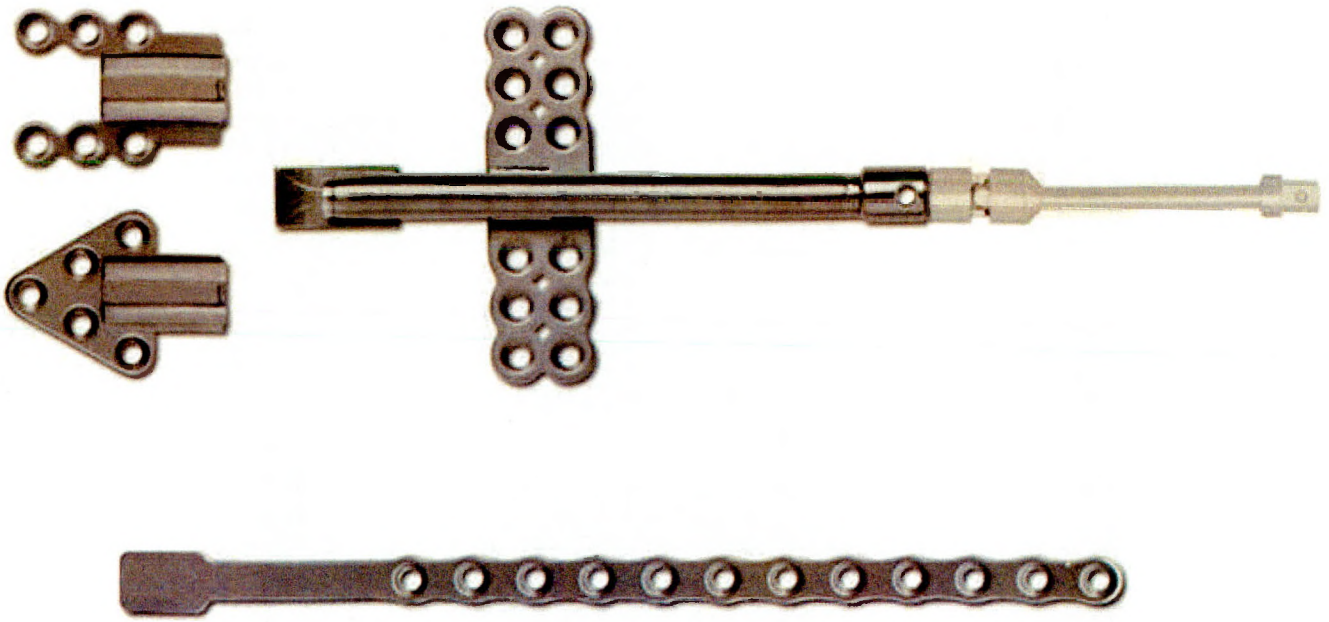


Fig. 7
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Editor-in-Chief,
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Respected sir,

Sub: Submission of manuscript titled "**Neocondyle Distraction Osteogenesis in the Management of Temporomandibular joint Ankylosis: report of five cases with review of literature**"

We are submitting a manuscript titled **"Neocondyle Distraction Osteogenesis in the Management of Temporomandibular joint Ankylosis: report of five cases with review of literature"** for publication in your esteemed journal. The authors are Dr. Ravi Sharma, Dr. R. Manikandhan, Dr. Sneha, Dr. P. Anantnarayanan, Dr. Naveen Kumar J. All applicable patient releases were obtained and are on file with the Corresponding Author.

Thanking you,

Dr. Ravi Sharma

Dr. R. Manikandhan





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