

Is Entire Removal of a Post-Traumatic Temporomandibular Joint Ankylotic Site Necessary for an Optimal Outcome?

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Purpose: Temporomandibular joint (TMJ) ankylosis that occurs after TMJ condylar fracture constitutes a treatment challenge. The purpose of the present study is shed light on an alternative treatment approach for certain such cases where the displaced condylar head or part of it can be detected in computed tomography. The leading principle of this protocol is accurate removal of the ankylotic mass only, leaving the condyle-disc apparatus un-touched.

Patients and Methods: The study is based on such cases of post trauma ankylosis where the displaced condyle was detected. Thirteen cases are reported (10 unilateral and 3 bilateral) age ranged from 8 to 51 years (mean 20). All patients were treated according to the presented protocol that emphasizes the significance of preserving the condyle-disc apparatus while accurately removing the ankylotic mass. To achieve the required precision, 3-dimensional computed tomography was used. An integral part of the treatment plan is intensive guided physiotherapy, which is intended to re-establish normal joint function, the original occlusion and facial symmetry (in growing individuals).

Results: The patients were followed up for 6 to more than 60 months. After guided physiotherapy, all patients had significant postoperative improvement in maximal mouth opening from a mean of 18.4 mm (range 8 to 28) to a mean of 41.2 mm (range 35 to 50). All patients had returned to their original occlusion. In all the growing patients, a marked improvement in facial symmetry was observed.

Conclusions: In post trauma ankylosis the displaced head of the condyle and disc should be searched for using computed tomography. If detected we recommend its preservation while accurately remove only the ankylotic mass. Using this approach, in addition to achieving adequate mandibular motion, good occlusion, and normal facial growth, major surgery, with all its inconveniences and potential complications, is avoided.

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Temporomandibular joint (TMJ) ankylosis often occurs after misdiagnosis, delayed treatment, inadequate surgery, prolonged immobilization, or insufficient physiotherapy for intracapsular or subcondylar fractures.^{1,2}

TMJ ankylosis affects facial growth potential² and, therefore, can lead to facial deformity; it is also associated with difficulties in breathing, biting, chewing, and swallowing and is commonly accompanied by

poor oral hygiene.^{1,3-7} This condition is challenging to treat, because it requires complete release of ankylosis followed by restoration of the condylar height to facilitate a full range of motion and good occlusion. A number of surgical techniques have been described for TMJ ankylosis, including gap arthroplasty⁸⁻¹³ interpositional arthroplasty,^{8,11,12,14-17} and after excision of the ankylotic mass, a variety of interpositional materials have been used.^{9,13,18-23} Furthermore, for recon-

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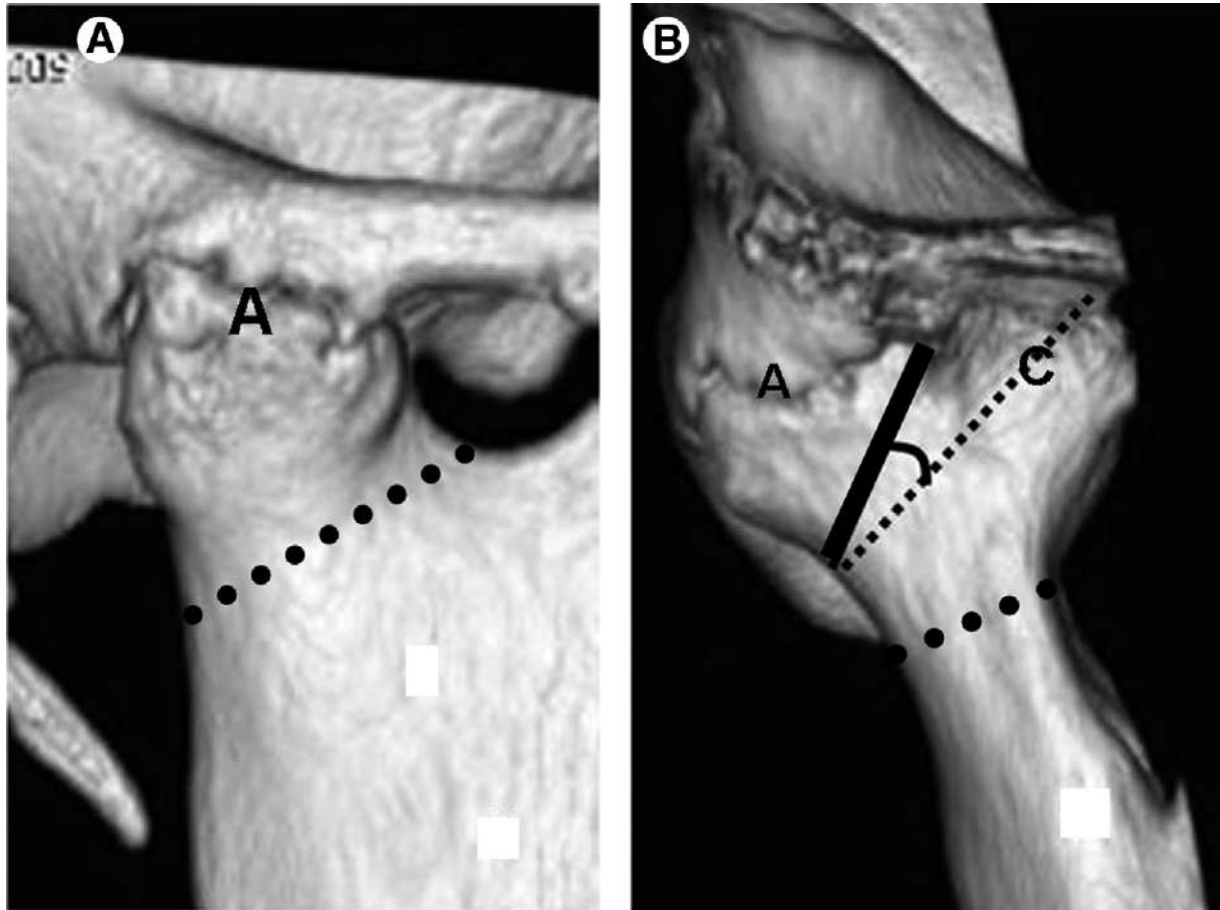


FIGURE 1. 3D-CT scan showing ankylosis of right TMJ. A, Lateral view of ankylotic site (A). Dotted line shows inferior surgical cut as recommended by Kaban protocol. B, Anterior view of ankylotic site (A) on lateral aspect and displaced condyle (C) in medial anterior inferior direction. Solid line shows inferior surgical cut recommended by presented protocol, a sharp angle separates the proper cut (solid line) from a potential improper cut (broken line) through the condyle. Dotted line indicates inferior surgical cut as recommended by Kaban protocol. (Figure 1 continued on next page.)

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struction of the ramus-condyle unit, assorted methods have been used, such as autogenous bone (including costochondral graft,^{15,24-26} fibula,^{27,28} clavicle,²⁹ iliac crest,^{30,31} and metatarsal head^{32,33}), alloplastic materials,³⁴⁻³⁹ and distraction osteogenesis.⁴⁰⁻⁴³ No consensus has been reached regarding the optimal strategy. Limited range of motion and reankylosis are the most frequently reported long-term complications.^{11,44} Facial asymmetry, facial nerve paresis, occlusal changes, overgrowth of the costochondral graft, unpredicted resorption of autogenous bone, and foreign body reactions to alloplastic materials are some of the complications that occur, clearly dependent on the surgical and reconstructive method used.⁴⁵

To achieve optimal outcomes, Kaban et al⁴⁶ established guidelines for the management of TMJ ankylosis. They emphasized that reankylosis occurs because of inadequate release of the ankylotic mass, which is associated with deficient passive mouth opening.^{2,46} Their 7-step protocol suggests aggressive excision of

the ankylotic mass and emphasizes the importance of the medial resection.^{2,46} In ankylosis that occurs after a displaced condylar fracture, the displaced fragment is bound to the medial aspect of the ankylotic site. When this occurs, their protocol strongly recommends removal of the entire ankylotic site, including the medial part, to enable free, passive jaw movement^{2,46} (Fig 1A,B). Fine-cut 3-dimensional computed tomography (3DCT) allows the identification of the location, extent, and anatomic relations of the area of ankylosis.²

The protocol from Kaban et al⁴⁶ has substantially improved the success rate of TMJ ankylosis treatment. We hypothesize that in cases with Sawhney's ankylosis type III,²¹ preserving the medially located condyle-disc apparatus will maintain inherent joint function, conserve the vertical height of the ramus, and, in children, protect the growth site. It is important to note that the disc is the optimal interpositional material, serving as a barrier and preventing fusion of the



FIGURE 1 (Cont'd). C, After digital resection of ankylosed site, according to presented protocol, condyle (C) is preserved.

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distal fragment with the glenoid fossa (ie, ankylosis and bony overgrowth are less likely to occur).⁴⁷ An additional advantage of this approach is that all the complications associated with reconstructive techniques are prevented.

In the presented protocol (which was previously described in 1998⁴⁸), the guiding principle is precise removal of the ankylosed mass only, leaving the condyle-disc apparatus untouched (Figs 1B,C, 3). The procedure is followed by intensive physiotherapy, with the aim of rehabilitating normal joint function and occlusion and facilitating the re-establishment of facial symmetry.

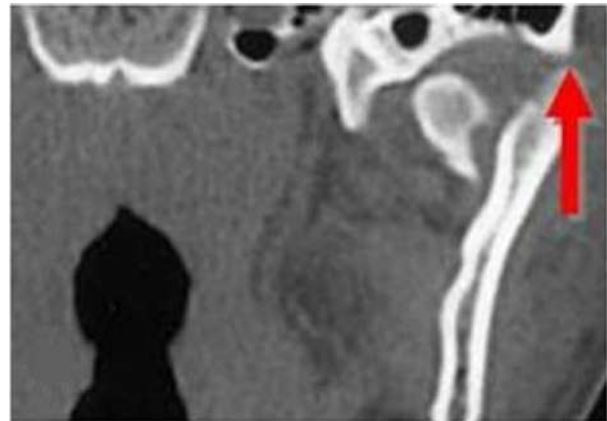
Patients and Methods

A total of 13 patients (4 males and 9 females, age range 8 to 51 years), who had been referred to the oral and maxillofacial surgery department with TMJ ankylosis with the displaced condyle bound to the

medial aspect of the ankylosis site, were included in the present study. The present report was retrospective and was exempted by the local institutional review board. The protocol presented aimed to attain comparable results to those achieved after proper closed reduction of displaced condylar fractures (Fig 2). ie, a well-functioning, short, inverted J-shaped condyle in a medial location associated with normal occlusion; (Figs 1B,C, 3). The signs and symptoms before and after treatment are summarized in Table 1.

TREATMENT PROTOCOL

1. Operate, especially on young patients, as soon as possible, after ensuring a full understanding of, and cooperation with, the essential postoperative requirements.



Following IMF

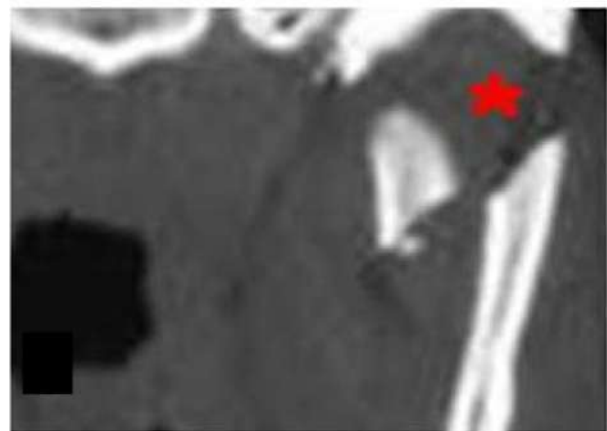


FIGURE 2. Subcondylar fracture. Upper, TMJ condyle is displaced and stump pulled up toward base of skull (arrow). Lower, After intermaxillary fixation, stump is pulled down (star) and occlusion corrected.

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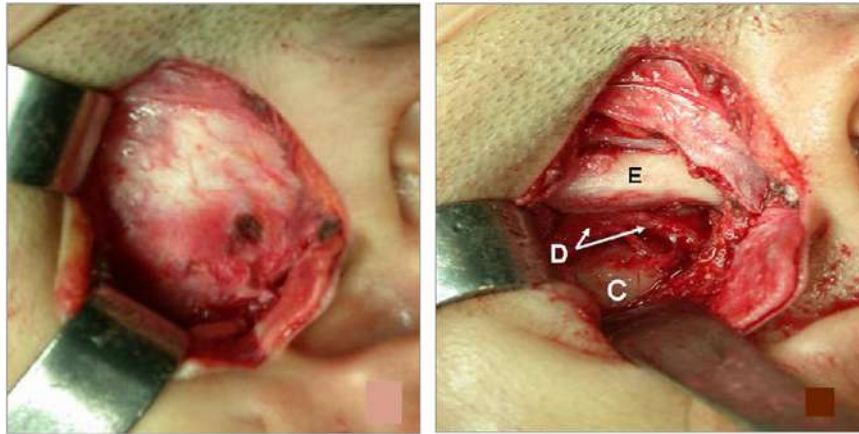


FIGURE 3. Typical surgical field of left TMJ ankylosis. *Left*, Lateral view of typical ankylotic site. *Right*, After resection of ankylosis, “previous” fossa and eminence (E), medially located condylar head (C), and disc (D) are exposed.

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- Use fine-cut 3DCT to plan the incision between the ankylotic site and displaced condyle (Fig 1B), considering the limited surgical field, that the displaced condyle and disc are hidden medially (Fig 1 to 3), and that a small error in the angle of the incision can cut through the condyle (Figs 1B,C).
- Resect the fibrous and/or bony ankylotic mass on the lateral aspect and leave about 2 cm distance from the base of the skull to the neck of condyle (Figs 1B,C, 3).
- Leave the condyle and disc untouched (Figs 1C, 3).
- Perform coronoidectomy on the affected side using either an intra- or an extraoral approach.
- Perform coronoidectomy on the contralateral side, using an intraoral approach, if steps 3 and 5 do not result in free maximal mouth opening (MMO).
- Suture the native disc (to cover the condyle) to the capsule, in a posterolateral direction. If, as is rarely observed (our experience included only 1 such case), the disc cannot be safely sutured to the capsule, the condyle should be separated from the “previous” (what used to be) fossa by an interpositional material. This can be done, for example, using a 2- to 3-mm-thick silicone sheet sutured to the presently unloaded fossa, applying stainless steel ligature wire 0.016 in.

Table 1. SIGNS AND SYMPTOMS BEFORE AND AFTER TREATMENT

Pt. No.	Ankylosis Location	Gender	Age (yr)	Preoperative Facial Symmetry (VAS 0-5)	Preoperative MMO (mm)	Postoperative Facial Asymmetry (VAS 0-5)	Postoperative MMO (mm)	Follow-Up (mo)	Comment
1	Rt	F	23	0	23	0	39	41	Deviation
2	Lt	F	9	4	22	1	41	>60	—
3	Lt	F	12	2	24	0	46	53	—
4	Lt	F	11	3	28	0	50	>60	—
5	Rt	F	11	3	22	0	42	56	—
6	Rt/Lt	M	23	1	8	1	35	>60	—
7	Rt/Lt	M	40	0	18	0	37	>60	Anterior cross-bite
8	Lt	F	25	1	22	0	40	>60	—
9	Rt	F	11	4	22	2	42	24	—
10	Rt/Lt	M	8	0	10	0	38	6 since second surgery*	2-mm Open bite
11	Rt	F	15	4	8	2	37	16	—
12	Lt	M	51	3	14	3	44	>60	—
13	Lt	F	11	3	18	0	44	>60	—

Abbreviations: Pt. No., patient number; VAS, visual analog scale; MMO, maximal mouth opening; Rt, right; F, female; Lt, left; M, male.

*Twenty-four months after first surgery.

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8. Early aggressive mobilization of the jaw to achieve normal mouth closing and opening and the best possible occlusion.^{8,48,49} In addition to existing principles,⁵⁰ we emphasize the following points. First, in securing the gained mouth opening, the patient should leave the operating room with an open mouth secured by a mouth probe for 24 hours. This enables the patient to see the results of the surgery and internalize his/her goal. Furthermore, the efficiency of the exercises is enhanced by starting from this position rather than from a closed mouth position. Second, and for the same reason, these patients should sleep with an open mouth (applying a mouth probe) as long as they are not able to freely open their mouth. Finally, during the day, the patients should exercise their mouth opening according to established guidelines.

Rehabilitation of Mouth Closure

In long-duration ankylosis, the unused closing muscles weaken. On release of the ankylosis, the mandible drops, and the patient is unable to close his/her mouth. Therefore, guidance for proper mouth closure should be provided.

Rehabilitation of Occlusion

A contralateral open bite is often observed immediately after surgery. Erich arch bars with rubber bands should be used during the night to guide the lower jaw to the desirable occlusion.

Case Reports

Of the 13 cases, 4 are reported in detail, with distinctive aspects of the pathologic features or treatment approach provided.

CASE 1

An 8-year-old girl was diagnosed with a left TMJ condylar fracture after being in a motor vehicle accident (in Table 1, this patient is listed as patient 5). Physiotherapy was recommended. Six months later, she was referred to the oral and maxillofacial surgery department at Hadassah Hospital because of progressive facial asymmetry. On clinical examination, facial asymmetry with the chin deviating to the left was noted (Fig 4A). Her MMO was 22 mm with deviation to the left (Fig 4B) and limited movements to the right. Forced mouth opening was not painful but showed resistance in the left TMJ. Protrusion was limited, as was deviation to the left. CT scanning (coronal sections) showed left TMJ ankylosis. Careful evaluation showed that the ankylosis was located on the lateral aspect of the TMJ, between the stump and the base of skull, and the displaced fractured condyle was facing medially toward the base of skull and its base was ankylosed to the medial aspect of the stump (Fig 4C).

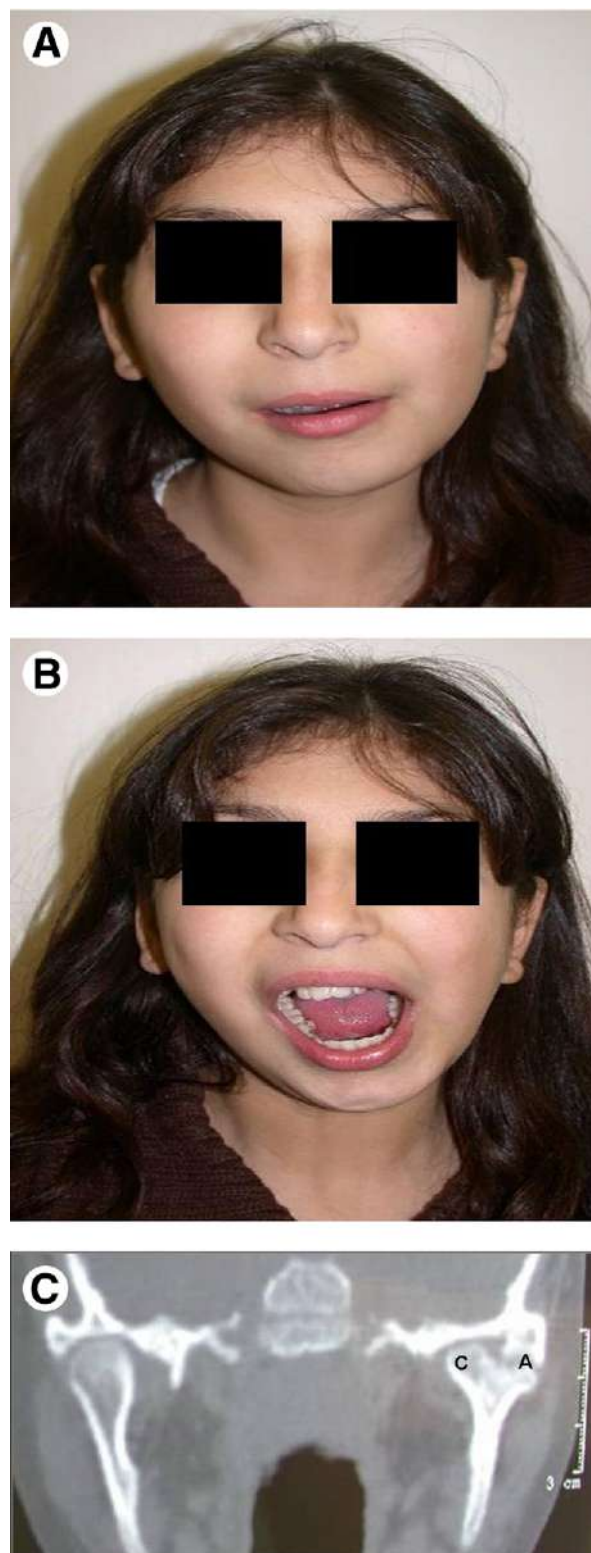


FIGURE 4. Case 1 (patient 5 in Table 1) 6 months after untreated left TMJ fracture. A, Facial asymmetry with deviation of mandible to left. B, Limited mouth opening with deviation to left. C, CT scan (coronal sections) showing left TMJ ankylosis (A) on lateral aspect of left TMJ between stump and base of skull. Displaced fractured condyle (C) faces medially.

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To prevent further progress of her facial asymmetry, surgery was performed immediately. The ankylotic site on the lateral aspect was aggressively removed, leaving 1.5 to 2 cm between the stump and the base of skull (Figs 1B, 3). In this condition, the condyle, covered by the disc, was observed on the medial aspect (Figs 1B, 3). The disc was then pulled and sutured to the lateral aspect of the displaced

condyle. No interpositional material was placed in the resected area. Because the movement was not yet free, ipsi- and contralateral coronoidectomies were performed. Free movement of the mandible with no deviation was then noted.

After 6 months of intensive physiotherapy, the patient presented with substantial improvement in facial symmetry with minor deviation of the mandible to the

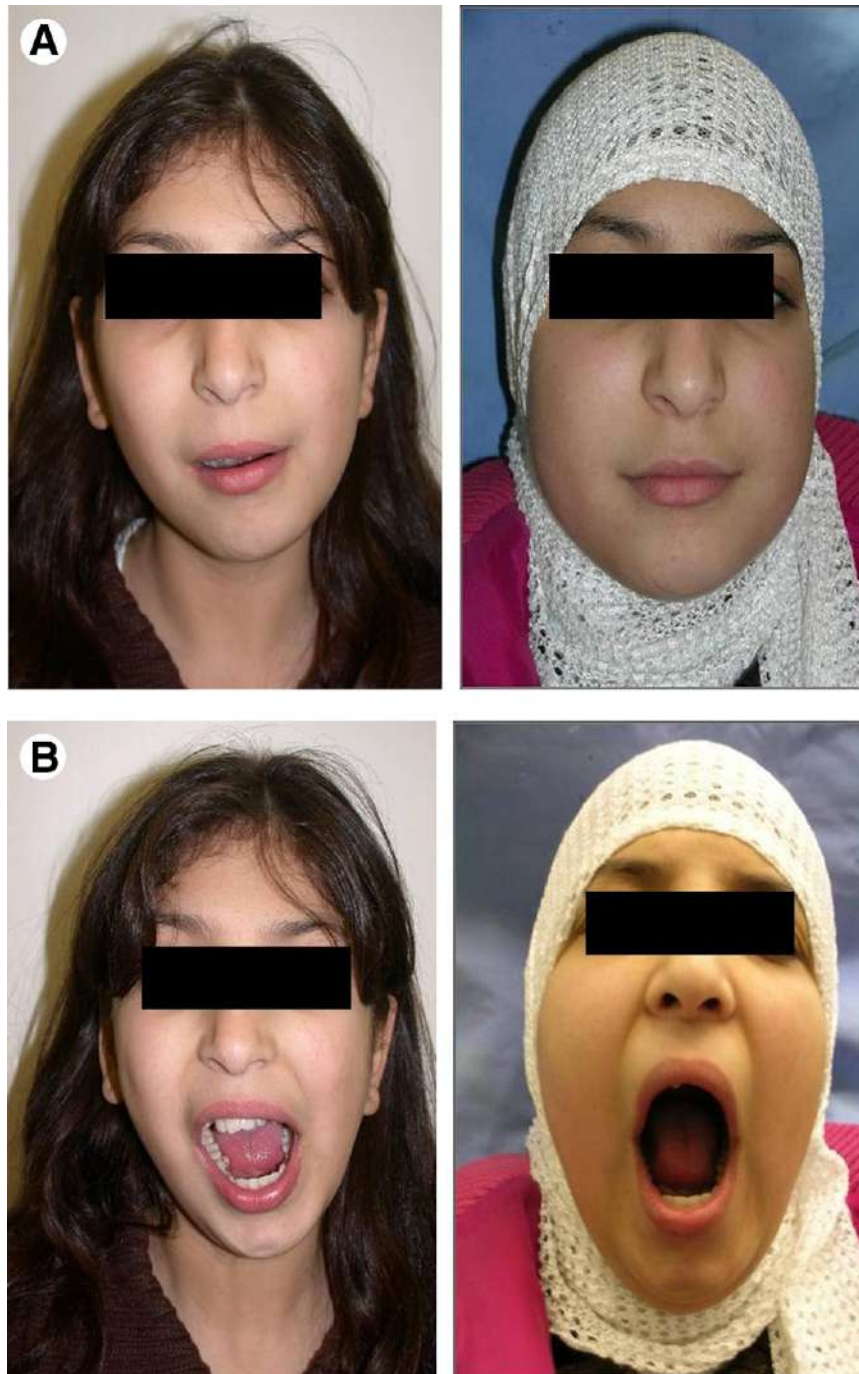


FIGURE 5. Case 1 (patient 5 in Table 1) 1 year after protocol-directed surgery. A, Marked improvement in facial symmetry. B, Marked improvement in MMO to 44 mm without deviation. (Figure 5 continued on next page.)

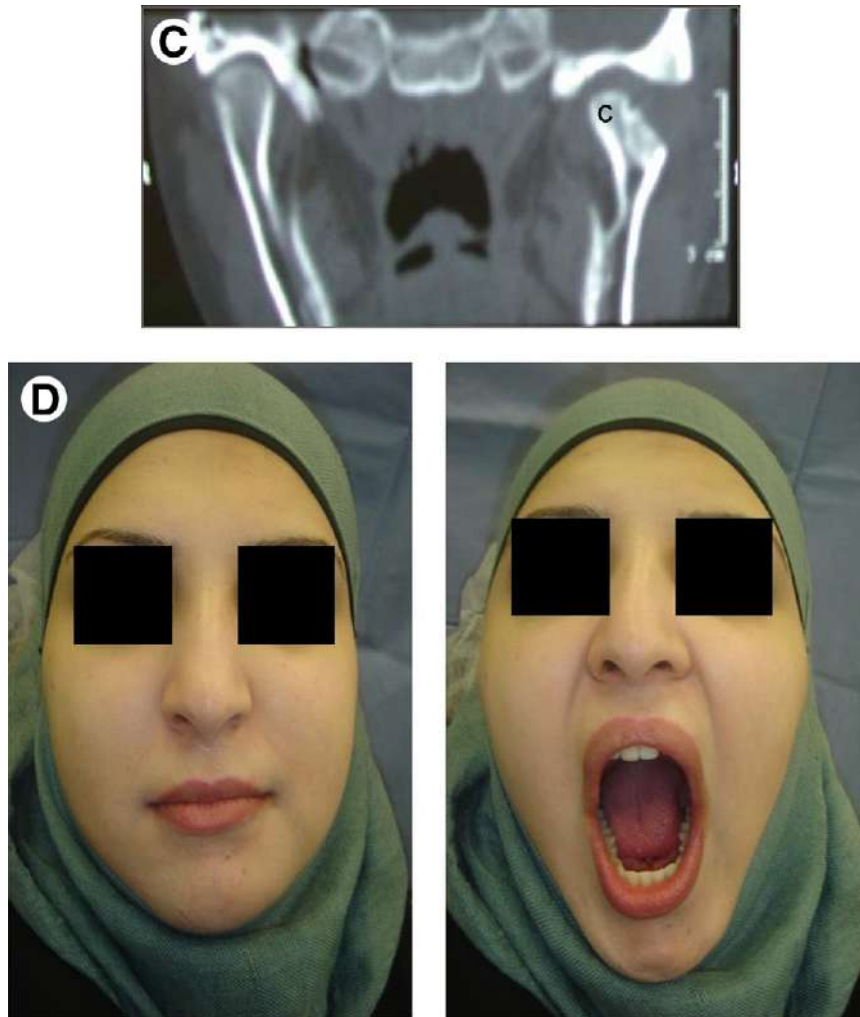


FIGURE 5 (Cont'd). C, CT scan (coronal view) showing preserved displaced head of condyle (C) after removal of ankylotic site. Inverted J-shaped condyle functions and grows. D, Patient's symmetry and MMO 8 years later.

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left (Fig 5A) and normal MMO without deviation (Fig 5B). All other mandibular movements were within normal limits, except for protrusion, which had a deviation to the left. CT (coronal view) showed an inverted J-shaped condyle located on the medial aspect, facing the base of the skull (Fig 5C). Figure 5D shows the patient's almost symmetric face with normal MMO 8 years after surgery.

CASE 2

A 23-year-old man was referred for evaluation after multiple surgeries for post-traumatic bilateral TMJ ankylosis that had occurred when he was 8 years old (in Table 1, this patient is listed as patient 6). He complained of severely limited mandibular movement that was becoming worse and described multiple surgeries that had attempted to release the ankylosis.

Clinical examination showed an almost symmetric "bird-face" deformity with poor oral hygiene, limited

mouth opening (8 mm; Fig 6A), and an open bite (Fig 6B).

3DCT of both sides of the skull showed right and left ankylotic sites, and no remnant of the original structure was detected (Fig 6C). However, a careful 3DCT study of each ankylotic site showed the "hidden" condylar head on the medial posterior aspect of the ankylosed left TMJ. Next to the condyle, an elongated and deformed coronoid process was hugged by the deformed zygomatic arch (Fig 6D). Evaluation of the right side showed the fibro-osseous ankylosis typically seen after multiple surgeries, with no remnants of the condyle.

The ankylosis on the left was released according to our protocol, leaving the condyle untouched. On the right side, after aggressive removal of the ankylotic site, a silicone block was sutured to the glenoid fossa region using 0.018-in stainless steel wires, forming a barrier between the stump and the base of the skull.

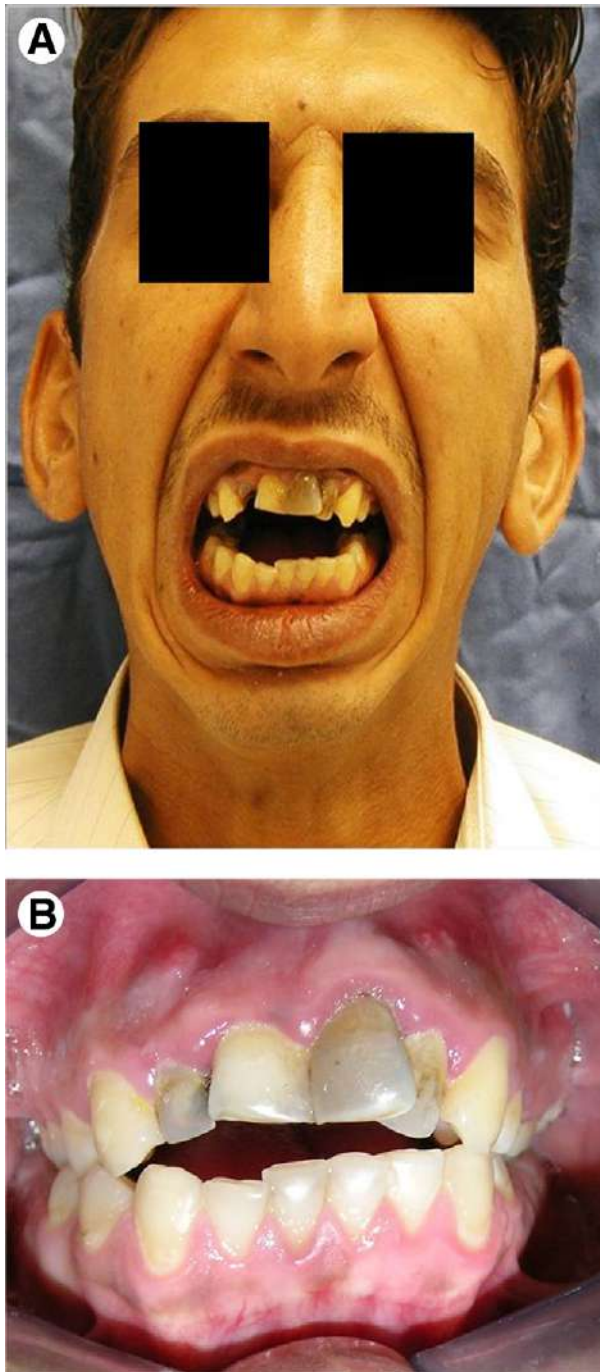


FIGURE 6. Case 2 (patient 6 in Table 1), with long-duration bilateral TMJ ankylosis. Patient presented with, *A*, severely limited mouth opening (8 mm including open-bite of 4 mm) and, *B*, anterior open bite and poor dental health. (Figure 6 continued on next page.)

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Surgery was followed by intensive physiotherapy for both mouth opening and closure to the original occlusion.

At 6 years of follow-up, the patient presented with an acceptable range of motion (MMO of 35 mm; Fig

7A) and unchanged occlusion (Fig 7B), taking into account previous multiple interventions and his long crowns. The patient was spared reconstructive surgery with its potential complications.

Postoperative 3DCT of the isolated preserved condyle showed the condylar head on the medial-posterior aspect of the stump. This condyle maintained function and vertical height of the ramus (Fig 7C).

CASE 3

A 9-year-old girl was referred to the oral and maxillofacial surgery department for evaluation of progressing facial asymmetry. The medical history showed that she had fallen and hurt her chin 2 years earlier with no further complaints (in Table 1, this patient is listed as patient 9). Extraoral examination showed facial asymmetry with chin deviation to the right (Fig 8A). The MMO was limited to 22 mm, with marked deviation to the right (Fig 8B). Lateral movements to the left were limited, and protrusion was also associated with deviation to the right. Intraoral examination showed a right cross bite with marked deviation of the mandibular midline to the right (Fig 8C). A panoramic radiograph vaguely showed the ankylosis (Fig 8D).

3DCT scan of the right ankylotic TMJ only showed a small part of the displaced condyle on the medial aspect of the ankylotic site (Fig 8E). We assumed that this remnant would be sufficient to act as a growth site and, therefore, decided to proceed according to our protocol. For optimal performance, a 3D model was used to carefully plan and perform the surgery without damage to the condyle.

At 2 years after surgery, the patient presented with improved facial symmetry (Fig 9A) and significant improvement in both mouth opening (Fig 9B) and occlusion (Fig 9C).

CASE 4

An 8-year-old boy had severely limited mouth opening with a slight anterior open bite (Fig 10A) and a symmetric face (Fig 10B) owing to bilateral ankylosis after trauma when he was 6 years old (this patient is listed as patient 10 in Table 1). CT showed bilateral bony TMJ ankylosis. The posterior view of the 3DCT model showed both condylar heads on the medial aspect (Fig 10C). Detailed study of the left TMJ showed complicated ankylosis with the damaged condyle in a medial anterior location, adjacent to the base of the skull. The angle between the accurate surgical line (Fig 10D, solid line) and the line (Fig 10D, interrupted line) that cuts through the condyle is narrow.

Despite the questionable prognosis, the patient was treated according to the protocol to maintain the growth potential of the condyles. The condyle-

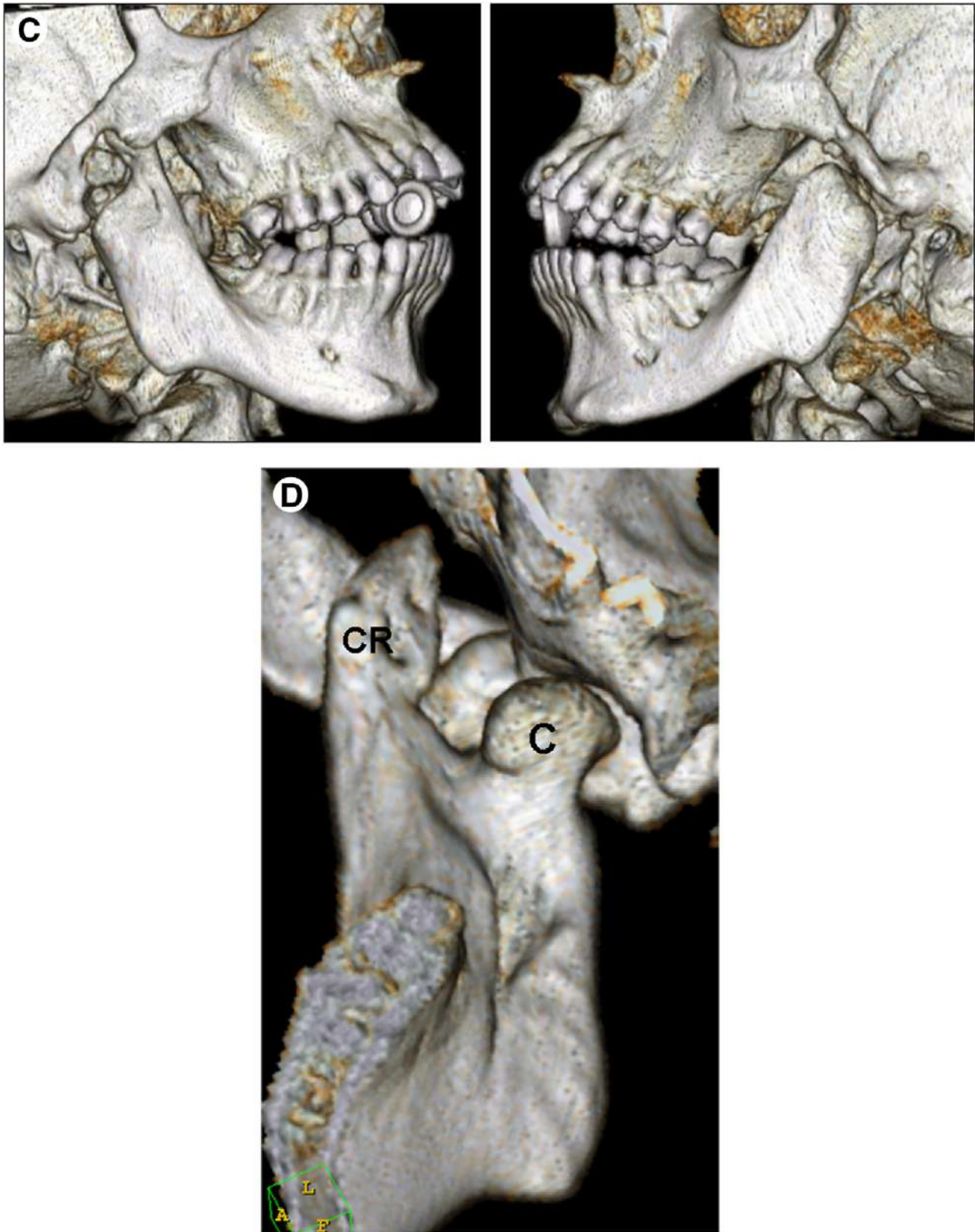


FIGURE 6 (Cont'd). C, 3DCT scan showing severe bilateral ankylosis with no indication of original TMJ structure. D, Careful study of 3DCT scan uncovered presence of condylar head (C) and elongated deformed coronoid (CR) process embraced by zygomatic arch on left side. Nitzan, Abu Tair, and Lehman. *Post Traumatic TMJ Ankylosis - An Alternative Treatment. J Oral Maxillofac Surg* 2012.

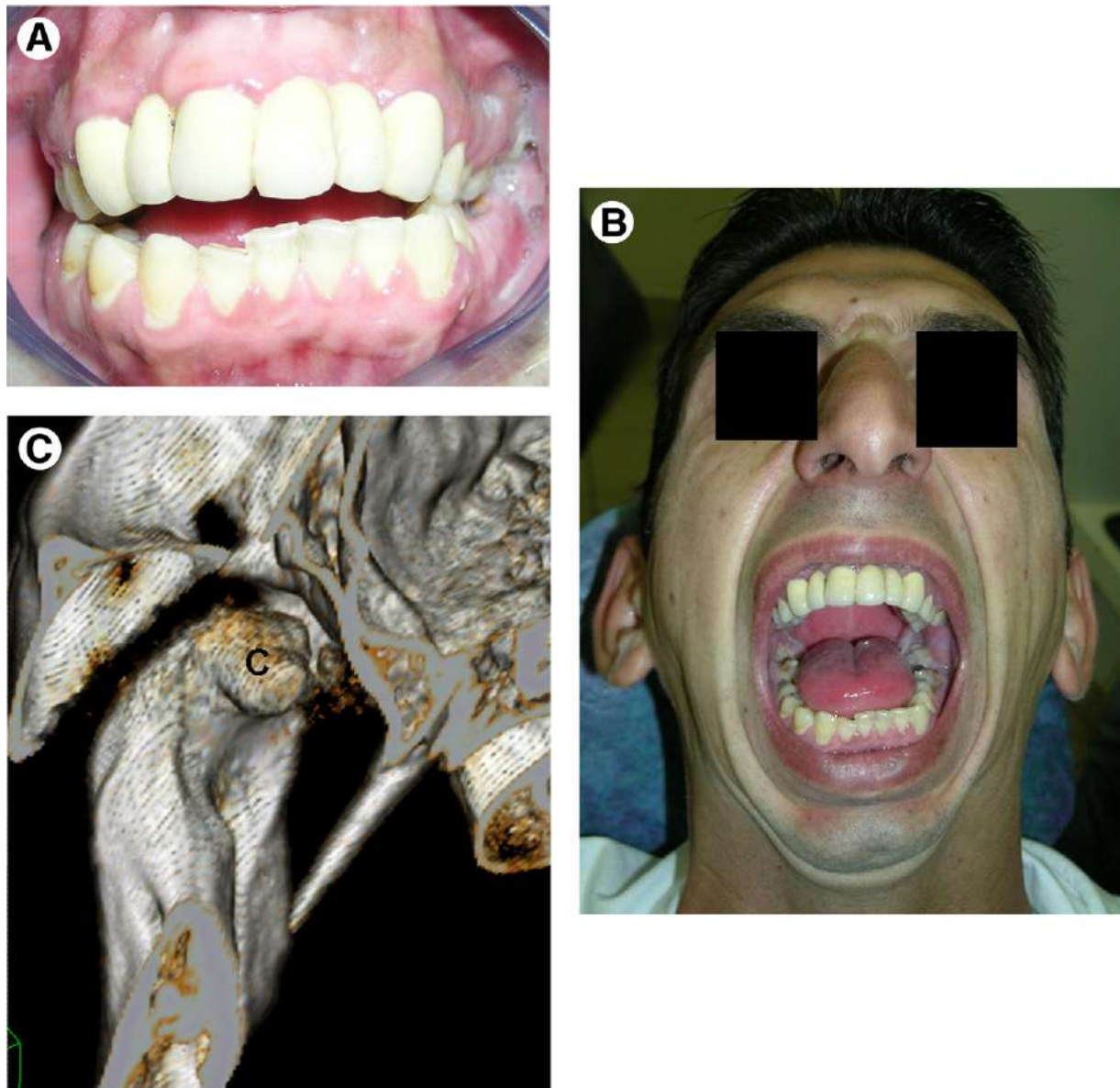


FIGURE 7. Case 2 (patient 6 in Table 1) 6 years after protocol-directed surgery on left TMJ. A, Original occlusion maintained. B, Acceptable range of motion (35 mm with open-bite of 4 mm). C, 3DCT scan showing preserved functioning left condyle (C) on medial aspect after elimination of both ankylosis site and left coronoid.

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disc apparatus on both sides was preserved, followed by intensive physiotherapy with the aim of preserving the MMO achieved during surgery and the preoperative occlusion. At 18 months of follow-up, the mandible, as often occurs, was slightly protruded, with an MMO of 40 to 44 mm and an open bite of 4 mm.

Starting at 18 months after surgery, the MMO had deteriorated to 20 to 30 mm. Another CT scan showed overgrowth of bone on the lateral aspect. It seems that during surgery, the lateral ankylotic mass on the lateral aspect was inadequately removed, implying that minor overgrowth had already affected the

MMO. More aggressive bone removal was therefore performed on the lateral aspect, and a 2-mm-thick silicone sheet was placed in this unloaded “extra-articular” site. During follow-up, his MMO increased back to 38 mm (Fig 11A,B).

Results

A total of 16 joints in 13 patients were treated according to the presented protocol. The patients included 4 males and 9 females. The patient age range was 8 to 51 years (mean 19.2). They were followed up for 6 to more than 60 months. After

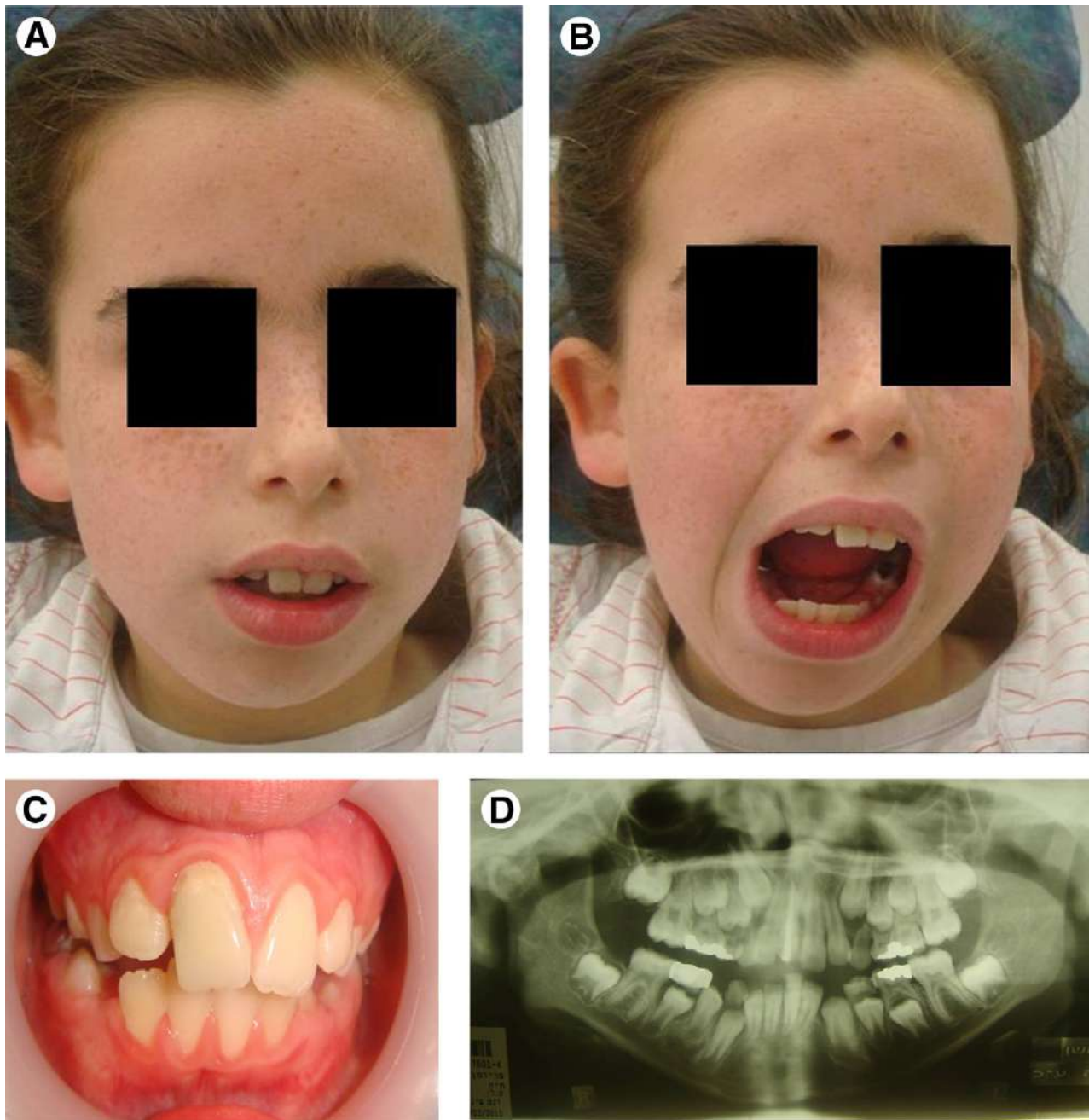


FIGURE 8. Case 3 (patient 9 in Table 1) was a 9-year-old girl complaining of developing facial asymmetry 2 years after minor trauma. *A*, Facial asymmetry, with deviation of chin to right. *B*, Limited mouth opening (22 mm), with deviation to right. *C*, Malocclusion with right cross bite. *D*, Panoramic view showing right TMJ ankylosis. (Figure 8 continued on next page.)

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guided physiotherapy, all patients had significant improvement in the MMO from a mean of 18.4 mm (range 8 to 28) to a mean of 41.2 mm (range 35 to 50) postoperatively. All the growing patients achieved good facial symmetry. In all the patients, except for one (patient 10 in Table 1), the occlusion returned to the original form after intensive physiotherapy period (Table 1). One patient underwent removal of aggressive bone growth at the

lateral aspect owing to insufficient bone resection at the first intervention (case 4 in the present report and patient 10 in Table 1).

Discussion

TMJ ankylosis is most commonly caused by a misdiagnosed or mistreated mandibular condylar fracture. In most of these cases, the fractured condyle or

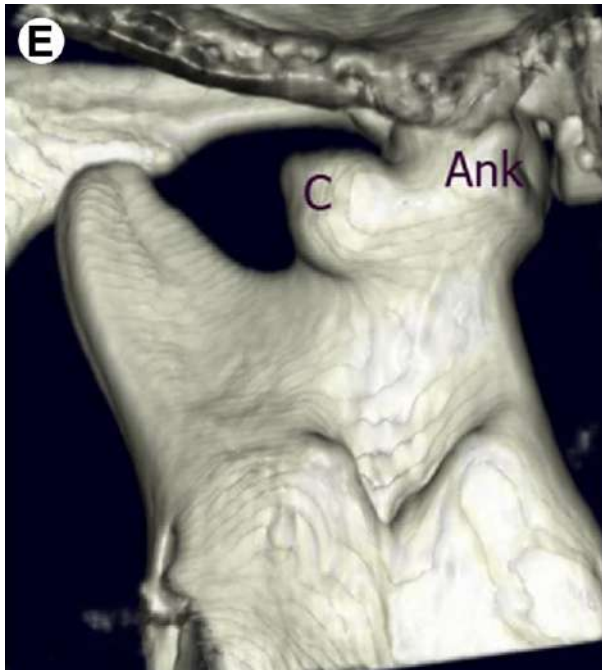


FIGURE 8 (Cont'd). E, 3DCT scan, medial view, showing right TMJ ankylosis (Ank); only a small part of the condyle (C) was found to be displaced medially.

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a part of it is displaced, and ankylosis (Sawhney's type III²¹) occurs between the stump and the base of the skull. In contrast, the displaced condyle is protected

from ankylosis by the displaced disc⁴⁷ (Fig 3). The present study focused on this group.

To clarify the rationale of the presented treatment, one needs to consider the entire sequence of events, starting with the fracture itself. In most cases of displaced subcondylar fractures, the head of the condyle, as described by Laskin,⁴⁷ is displaced, together with the disc, in an anteromedial-inferior direction.^{7,51-53} At the same time, the stump is pulled up by the ipsilateral closing muscles (masseter and medial pterygoid) toward the base of skull (Fig 2), resulting in typical malocclusion (ie, ipsilateral premature contact and a contralateral open bite).⁵⁴

Two main approaches have been used to correct this condition: open reduction, in which the condyle is exposed surgically, reduced, and fixed to its anatomic location; and closed reduction, in which the teeth are brought back into occlusion by intermaxillary fixation, and the stump is retracted away from the base of the skull. The condyle, however, is not reduced to the correct position owing to the attached pulling muscles (Fig 2). Intermaxillary fixation is limited to 10 to 14 days and is followed by intensive physiotherapy with the aim of rehabilitating normal jaw movement and ensuring stable normal occlusion. Both are achieved, although the inverted J-shaped condyle is located medially with some loss of vertical height (Fig 2).⁵⁵

Ankylosis typically develops because of incorrect treatment. This includes extended use of intermaxil-



FIGURE 9. Case 3 (patient 9 in Table 1) 2 years postoperatively. A, Improved facial symmetry. (Figure 9 continued on next page.)

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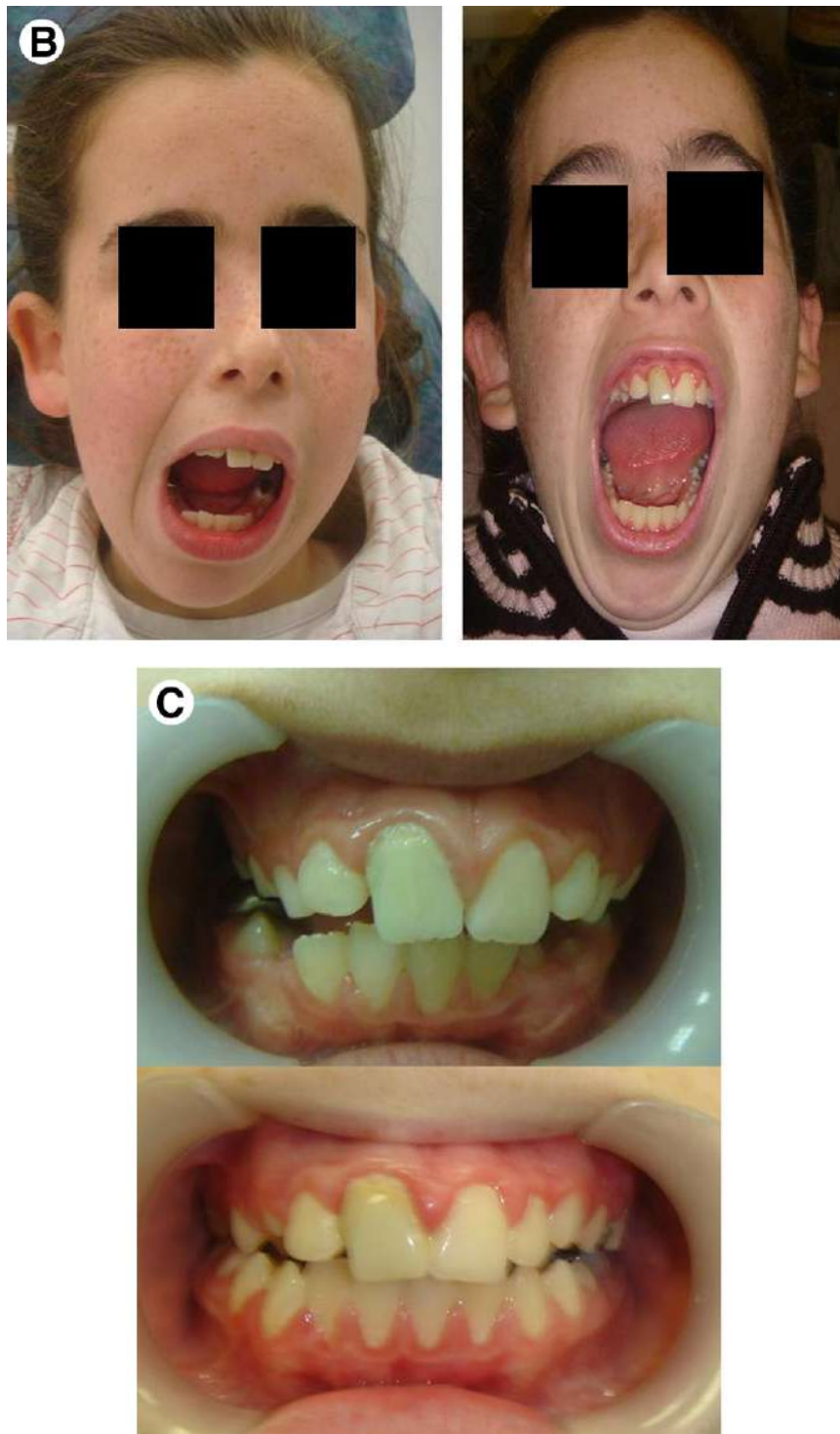


FIGURE 9 (Cont'd). B, Normal MMO with slight deviation to right. C, Improved occlusion without cross bite and less midline deviation (before orthodontic treatment).

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lary fixation, improper postoperative physiotherapy with a lack of guidance and follow-up or, alternatively, insufficient patient cooperation. To avoid the latter undesirable situation, we only operate on pa-

tients showing commitment to postoperative mutual responsibility.

Laskin⁴⁷ showed that the presence of the disc prevents ankylosis, and in experimental subcondylar frac-

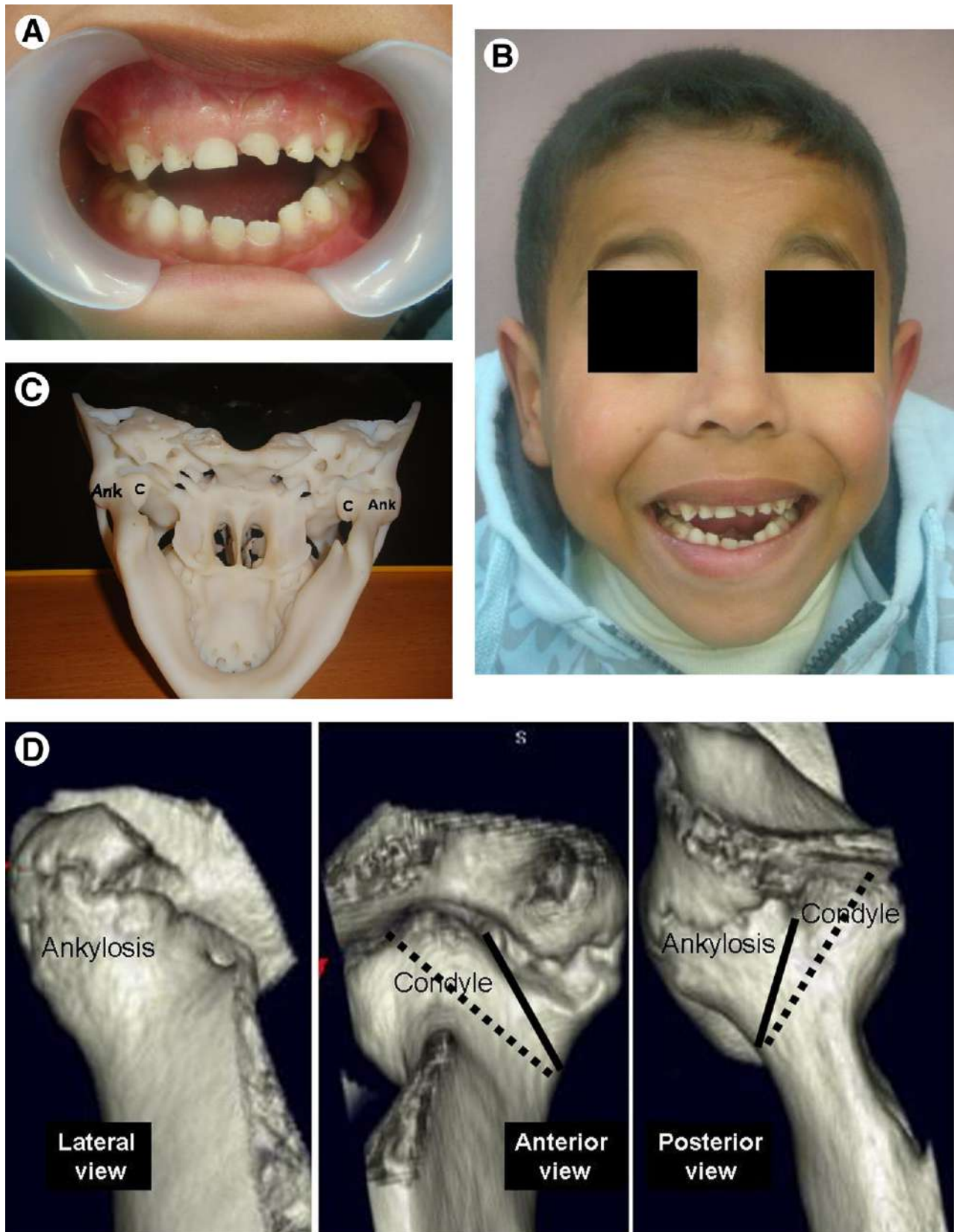


FIGURE 10. Case 4 (patient 10 in Table 1) was an 8-year-old boy with bilateral TMJ ankylosis 2 years after trauma. A, Severely limited mouth opening (10 mm, including open bite). B, Good facial symmetry. C, Surgical planning with close view at left ankylotic site from lateral, anterior, and posterior views. Note, damaged condyle located close to base of skull. D, 3D model showing bilateral TMJ ankylosis (Ank) with condyles (C) displaced medially.

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FIGURE 11. Case 4 (patient 10 in table 1) 18 months after protocol-directed surgery. A, Normal MMO (>40 mm). B, Increased anterior open bite that developed from rotation of free mandible after surgery corrected gradually with guided physiotherapy.

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tures with meniscectomy and immobilization, ankylosis of the condylar head was noted.

The presented protocol aimed to reverse the condition of ankylosis between the stump and the base of the skull and achieve results similar to those achieved with closed reduction (ie, a well-functioning short, inverted J-shaped condyle in a medial location associated with normal occlusion; Fig 2). In addition to the avoidance of unnecessary, high-risk, deep dissection and osteotomies to remove the displaced native condyle, this approach is particularly important for growing individuals, because it maintains the growth site and allows normal and symmetric development of the mandible. Other alternative surgical interventions are extensive, associated with a loss of the growth site and vertical height, and require reconstruction with its associated complications.

It is important to note that postoperatively the mandible is not always as free as was recommended by Kaban et al,⁴⁶ especially regarding contralateral movements, owing to the location of the condyle; therefore, long-term postoperative physiotherapy is required.

We have reported on 13 cases (10 unilateral and 3 bilateral), of which 4 were described in detail. All were treated according to the protocol presented. In brief, releasing the ankylosis, avoiding damage to the displaced condyle, guidance of the saved condyle to enable a normal range of joint function, good occlusion, and, in children, growth and establishment of good facial symmetry. This method challenges the

approach recently suggested by Long et al¹⁴ to release the ankylosis, redesign a form of condyle at the ankylositic site, remove the medially displaced condyle, and mobilize the disc over the preserved lateral stump. It also challenges the approach of Li et al,¹⁷ who used the stump to reconstruct a new TMJ with the disc repositioned over it. These approaches might provide proper vertical height; however, the first is associated with the undesirable removal of the growth site in children and involves removal of the invisible condyle, which is demanding and risky. Also, the second approach recommends a pointless repositioning of the disc. When our protocol is followed, although some loss of vertical height can occur, normal function and occlusion are restored, and the condyle serves as an articulation and a growth site.

Considering that ankylosis occurs as a result of numerous fracture types, various types of ankylosis develop. For optimal evaluation, 3DCT imaging is required (Figs 1, 6D, 7C, 8E, 10D). Occasionally, a 3D model (case 3 in Fig 8E and case 4 in Fig 10C) is beneficial to show the exact condyle location and shape and enable adequate surgical planning to avoid damaging the condyle or the disc, especially because the surgical field is limited and the condyle is hidden on the medial aspect of the ankylosis. Figures 1 and 3 show the risk of damaging the condylar head. In case 2, after 15 years of ankylosis and 5 surgical interventions, 3DCT showed the hidden undamaged condyle, which was saved (Figs 6D, 7C) and provided satisfactory results: sufficient vertical height, good occlusion,

and proper function, preventing the need for joint replacement.

There are 4 aims of surgical intervention for TMJ ankylosis that we desire to accomplish:

1. Preserve the range of motion accomplished at the end of surgery. All the present patients had significant improvement in MMO (35 to 50 mm, mean 41.2). Owing to the medial location of the displaced condyle, the contralateral movements might be limited.
2. Attain mouth closure. Longstanding ankylosis causes a lack of tonus in the closing muscles, because the mandible was supported by the ankylosis. Thus, the mandible often falls forward when the ankylosis is released. Physiotherapy, therefore, includes rehabilitation of the ability to close the mouth, as well as to chew and bite effectively.
3. Return to the original occlusion. Usually, after release of longstanding ankylosis, changes occur in occlusion. When bilateral ankylosis is released, the mandible moves forward and rotates clockwise, resulting in an increased anterior open bite. Release of unilateral ankylosis can cause a contralateral open bite because of the loss of vertical height owing to the relatively inferior location of the displaced condyle. These situations are solved by guided physiotherapy.
4. Enable growth of the mandible/facial structures (Table 1, patients 2, 3, 4, 5, 9, 10, and 13). Of those reported in detail (cases 1 and 3), surgery was performed during the growth period. Thus, restoration of symmetric function and resumption of facial, almost symmetric, growth rapidly ensued (Figs 5A, 5D, 9A).

The details of case 3 highlight that growth can continue with maintenance of the vertical height, even when only a part of the condyle is saved, which can occur in cases of split condylar fractures (Figs 8, 9). This case was treated according to our protocol, and the remaining part of the condyle functioned as a growth site. At 2 years of follow-up, the facial symmetry had improved, the occlusion was satisfactory, and the MMO was normal and almost symmetric (Fig 9). The surgical intervention in this case was also guided by 3DCT, emphasizing, once again, the importance of imaging to avoid damaging the hidden condyle.

In summary, the present study reports on a complementary protocol to that of Kaban et al, suggesting that not all cases of TMJ ankylosis require aggressive treatment. Surgeons should evaluate the option of releasing the lateral ankylosis while preserving the condyle and the disc. This procedure will allow the

patient to avoid major surgery, with all its inconveniences and complications, but still gain adequate mandibular motion and facial growth.

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