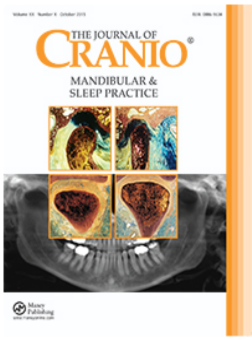

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TMJ

Adolescent internal condylar resorption (AICR) of the temporomandibular joint can be successfully treated by disc repositioning and orthognathic surgery, part 2: Treatment outcomes

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ABSTRACT

Objective: To evaluate treatment outcomes for patients with TMJ adolescent internal condylar resorption (AICR) treated by a specific surgical protocol, including: (1) Removal of bilaminar tissue surrounding the condyle, (2) Articular disc repositioning with Mitek anchor technique, and (3) Concomitant orthognathic surgery.

Methods: This study evaluated 24 AICR patients treated by the specific surgical protocol with clinical subjective and objective examinations and lateral cephalogram assessments for surgical changes and long-term outcomes.

Results: Mean age at diagnosis was 16.5 years, and mean follow-up was 30.3 months. All 24 patients had significant reduction in TMJ pain, facial pain, and headaches, with improvement in jaw function, diet, and disability. Cephalometric analysis showed significant surgical changes but good long-term occlusal and skeletal stability.

Conclusion: Patients with AICR treated with the specific surgical protocol demonstrated good skeletal and occlusal stability as well as improvement in TMJ pain, headaches, jaw function, diet, and disability.

KEYWORDS
Adolescent internal condylar resorption; AICR; condylar resorption; mandibular condyle; temporomandibular joint; maxillofacial surgery; counterclockwise rotation; Mitek anchor

Introduction

Adolescent internal condylar resorption (AICR) is a specific condition affecting the temporomandibular joints (TMJ) and predominately occurs in teenage females with onset during the pubertal growth phase [1,2]. AICR has also been inappropriately referred to as idiopathic condylar resorption, idiopathic condylysis, condylar atrophy, progressive condylar resorption, and cheerleader syndrome [3–16]. AICR causes mandibular condylar resorption with loss of volume and vertical dimension of the condyle, creating occlusal and musculoskeletal instability, resulting in the development of dentofacial deformities, TMJ dysfunction, and pain [1,2].

A number of other local and systemic pathologies or diseases can cause mandibular condylar resorption. Local factors include: osteoarthritis, reactive arthritis, avascular necrosis, infection, and traumatic injuries. Connective tissue and autoimmune diseases that can cause TMJ condylar resorption include: juvenile idiopathic arthritis, rheumatoid arthritis, psoriatic arthritis, scleroderma, systemic lupus erythematosus, Sjögren's syndrome, ankylosing spondylitis, and others. AICR is a specific TMJ pathology different from all of these other disease processes. Therefore, it has a distinct diagnostic presentation and treatment protocol.

Previous publications have detailed the nature of the pathological process, the clinical, radiographic, and MRI characteristics of AICR [1,2,17]. Patients with AICR may have some or all of the following characteristics: (1) Onset between the ages of 11 and 15 years during the pubertal growth years; (2) Predominately teenage females (83%); (3) Usually occurs bilaterally but can be unilateral; (4) High occlusal plane angle (HOP) facial morphology with retruded mandible and maxilla; (5) Class II occlusion with tendency for open bite; (6) Slow progressive condylar resorption (rate 1.5 mm per year) and mandibular retrusion; (7) Decreased oropharyngeal airway with sleep apnea in the more severe cases; (8) Hypertrophied turbinates and nasal airway obstruction; (9) Headaches,

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TMJ pain, clicking, TMJ and jaw dysfunction, ear symptoms etc., but 25% of AICR patients are asymptomatic, relative to pain and TMJ noise; and (10) MRI will show small condyles, anteriorly displaced articular discs with or without reduction, and amorphous tissue surrounding the condyle [1,2,17].

Wolford [1,2] developed an effective and predictable method to treat AICR when the condyles and articular discs are salvageable: (1) Removal of the hyperplastic synovial tissue surrounding the condyle; (2) Reposition and stabilize the articular disc to the condyle using a Mitek mini anchor (Mitek, Inc., Westwood, MA, USA) and two 0-Ethibond sutures (Ethicon Inc., Somerville, NJ, USA) attached to the anchor, functioning as artificial ligaments [18–24]; and (3) Double-jaw orthognathic surgery with counterclockwise rotation of the maxillo-mandibular complex to correct the associated jaw and occlusal deformities. Bilateral mandibular ramus osteotomies with rigid fixation are performed after the TMJ procedures, followed by the maxillary osteotomies, rigid fixation, and any additional ancillary procedures indicated. This treatment protocol effectively eliminates the TMJ pathology and corrects the functional and esthetic dentofacial deformity with one surgical operation [1,2]. If surgeons prefer, the TMJ surgery can be done as a separate procedure from the orthognathic surgery, but the TMJ surgery must be done first. It has been documented that counterclockwise rotation of the maxillo-mandibular complex is a very stable procedure in the presence of healthy jaw joints [25–27].

The authors' hypothesis is that patients with AICR and salvageable condyles and articular discs can have a stable surgical outcome, including decreased pain and improved jaw function, using the specific surgical protocol described in the previous paragraph. The aims of the study are to evaluate the surgical outcomes relative to: (1) Skeletal and occlusal stability; (2) Jaw function for maximal incisal opening and excursive movements, and (3) Quality of life effects relative to pain, jaw function, diet, and disability.

Materials and methods

In this retrospective study, the records of patients diagnosed and surgically treated with bilateral AICR from a single private practice (LMW) were evaluated. Inclusion criteria were: (1) Diagnosis of bilateral AICR by clinical, radiographic, and MRI assessments; (2) Surgically treated with a specific surgical protocol; (3) 10 to 20 years of age at initial consultation; (3) No previous history of TMJ and jaw surgery or trauma; (4) No other body joints affected; (5) No known congenital, syndromic, systemic or other local conditions, diseases, or pathological processes present; and (6) Adequate records with a minimum of six months presurgical evaluation and one year post surgical follow-up. There were no specific exclusion criteria that differed from the inclusion criteria. IRB Approval was obtained from the Biomedical Institutional Review Board of Methodist University of Sao Paulo, Brazil (CAEE: 0005.0.214.000-11).

All patients had presurgical and post surgical orthodontic treatment and were out of treatment prior to T4 (longest follow-up) records. All patients received a specific single-stage surgical protocol, including: (1) Removal of the synovial and bilaminar tissues surrounding the condyles, (2) Repositioning the articular discs with Mitek anchors and artificial ligaments, and (3) orthognathic surgery with counter-clockwise advancement rotation of the maxillo-mandibular complex operated by the same surgeon (LMW).

All patients underwent clinical evaluations using standardized forms and radiographic examination at the following intervals: initial consultation (T1), immediately presurgical (T2), immediately post surgical (T3), and longest follow-up (T4). Imaging included; (1) Lateral cephalometric radiographs, (2) TMJ tomograms, and (3) panographic radiographs. Cephalometric radiographs and TMJ tomograms were taken on the same machine (Quint Sectograph, American Dental Co. Hawthorne, CA, USA). MRI imaging was acquisitioned presurgery at T1.

One examiner performed the patients' subjective and objective evaluations, and data was recorded on standard data forms. For this study, data were compared at presurgery (T1) and longest follow-up (T4) time intervals. Subjective evaluations (Table 1) were performed utilizing Likert scales for: (1) TMJ pain (*TMJP,* 0 = no pain; 10 = worst pain imaginable), (2) Headaches (*HA,* 0 = no pain; 10 = worst pain imaginable), (3) Myofascial pain (*MFP,* 0 = no pain; 10 = worst pain imaginable), (4) Jaw function (*JawFn,* 0 = normal function; 10 = no movement), (5) Diet (*Diet,* 0 = no restriction; 10 = liquid only), and (6) Disability (*DISAB,* 0 = no disability, 10 = totally disabled). The subjective assessment questions relative to *TMJP, HA, MFP, JawFn, Diet, and DISAB* are listed in Table 1.

For objective evaluation, presurgery maximum incisal opening (MIO) and lateral excursions were compared to the longest follow-up records. Objective functional assessments measured the MIO and lateral excursion movements at T1 and T4. MIO measurements used a ruler with the jaws at maximum opening without assistance, measuring between the lower and upper incisors tips. In cases of anterior open bite, the amount of open bite was subtracted from the maximal opening. With anterior deep bite, the amount of vertical dental overlap was added to the opening to record the actual result. Left and right maximum excursion without assistance was determined by

Table 1. The subjective Likert numerical scales and objective assessments.

TMJ pain	No pain	0-1-2-3-4-5-6-7-8-9-10	Worst pain imaginable
Headache	No pain	0-1-2-3-4-5-6-7-8-9-10	Worst pain imaginable
Facial pain	No pain	0-1-2-3-4-5-6-7-8-9-10	Worst pain imaginable
Jaw function	Normal	0-1-2-3-4-5-6-7-8-9-10	Cannot move
Diet	No restriction	0-1-2-3-4-5-6-7-8-9-10	Just liquids
Disability	None	0-1-2-3-4-5-6-7-8-9-10	Total
Maximal mouth opening	________ mm		
Left mandibular movement	________ mm		
Right mandibular movement	________ mm		

Notes: Questions asked: (1) Rate your average daily level of TMJ Pain on a scale of 0–10 where 0 equals no pain and 10 equals worst pain imaginable. (2) Rate your average daily level of Headache on a scale of 0–10 where 0 equals no pain and 10 equals worst pain imaginable. (3) Rate your average daily level of Facial Pain on a scale of 0–10 where 0 equals no pain and 10 equals worst pain imaginable. (4) Rate your Jaw Function; which is the ability to open your jaw, move it side to side, and chew, where 0 equals normal function without any impairment and 10 equals no function; jaws are "frozen." (5) Rate your Diet where 0 equals the ability to chew any consistency of food without difficulty and 10 equals liquids only. (6) Rate your average daily level of Disability on a scale of 0–10 where 0 equals no disability and 10 equals totally disabled.

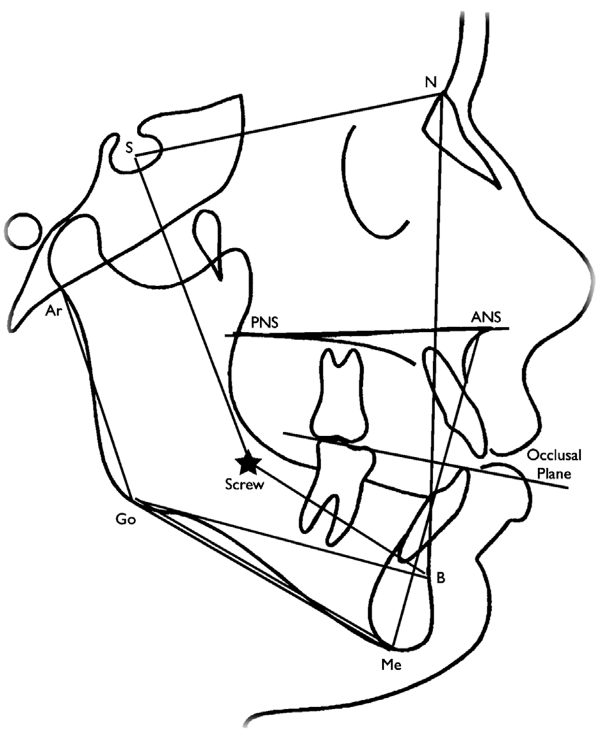

Figure 1. Cephalometric tracing and analysis of specific anatomical landmarks as defined in Table 2, to calculate the linear and angular changes between the cephalometric time intervals (T1, T2, T3, and T4).

using a ruler to measure the shift between the upper dental midline and the alignment of the lower arch, starting from centric relation.

Reliability of cephalometric measurements

For obtaining the intra examiner error, 20 randomly selected cephalograms were traced and measured again, after a minimum period of two months. To check the systematic error, the paired *t*-test was used. In determining the casual error, the error calculations used were proposed by Dahlberg [28,29].

Statistical analysis

The data are described in the Tables through the parameters of mean and standard deviation. To verify that the groups had normal distribution, the Kolmogorov–Smirnov test was used. Only the measurements related to facial pain, TMJ pain, headache, and disability did not pass by the criterion of normality.

In comparing the two time intervals (T1 and T2) of the measurements that have not gone through the normal criterion, the non-parametric Wilcoxon test was used. For those that passed through the normal criterion, the paired *t*-test was used.

For the purpose of comparing the four time intervals (T1, T2, T3 and T4), analysis of variance to a criterion for repeated measurements was used, and *post hoc* Tukey for multiple comparisons.

Lateral cephalograms at T1, T2, T3, and T4 were traced (Figure 1) and superimposed by a single examiner (AG) to analyze specific landmarks for linear and angular measurements (Table 2) and calculate presurgical change (T2-T1), surgical change (T3-T2), and long-term stability (T4-T3). The paired *t*-test was used to compare the measurements made only in T3 and T4, at a significance level of $p \leq 0.05$.

Results

Of the 24 patients meeting the inclusion criteria, 20 were females (83%) and 4 were males (17%). Materials evaluated included 96 lateral cephalograms and 48 standardized questionnaires of pain and mandibular function.

Objective and subjective variables

The average patient age at initial evaluation was 16.5 years (range 13 to 20 years), and mean follow-up was 30.3 months (range 12 to 72 months). Comparing presurgery to longest follow-up data, all 24 patients had subjective evaluations that were statistically improved: Facial pain improved from 4.5 (± 2.6) to 1.4 (± 2.3)

Table 2. Cephalometric analysis.

Cephalometric landmarks	
S: Sella	Go: Gonion
N: Nasion	Me: Menton
B: Point B	Ar: Articular
PNS: Posterior Nasal Spine	OP: Occlusal Plane
ANS: Anterior Nasal Spine	
Angular measurements	
SNB: Angle formed by a line from Sella to Nasion and a line from Nasion to Point B representing the antero-posterior position of the mandible.	
SN–PNS/ANS: Angle formed by a line from Sella to Nasion and a line from posterior nasal spine to anterior nasal spine representing the palatal plane angle.	
SN-Go-Me: Angle formed by a line from Sella to Nasion and a line from Gonion to Menton representing the mandibular plane angle.	
SN–P: Angle formed by a line from Sella to Nasion and a line tangent to the mandibular occlusal plane representing the occlusal plane angle.	
Linear measurements	
Ar-Go: Line from Articular to Gonion.	
Go-Me: Line from Gonion to Menton.	
Go-B: Line from Gonion to Point B.	
ANS-Me: Line from Anterior Nasal Spine to Menton.	
Screw-Me: Line from the superior screw in ramus to Menton.	
Screw-B: Line from the superior screw in ramus to Point B.	
Screw-S: Line from the superior screw in ramus to Sella.	

Table 3. Comparison between T1 and T4 for subjective and objective variables.

	Presurgery (T1)		Longest follow-up (T4)			
Variables	mean	SD	mean	SD	dif.	*p*
TMJ pain	4.71	2.80	0.92	2.38	−3.79	<0.001*
Headache	3.88	3.15	1.44	2.47	−2.44	0.003*
Facial pain	4.50	2.59	1.40	2.26	−3.10	<0.001*
Jaw function	4.83	1.79	1.50	1.59	−3.33	<0.001*
Diet	3.46	2.64	1.42	1.56	−2.04	<0.001*
Disability	2.42	2.04	0.29	0.62	−2.13	<0.001*
Max. Mouth opening (mm)	42.21	9.19	43.52	5.74	1.31	0.453 ns
Right lateral movement (mm)	7.40	2.35	4.67	2.01	−2.73	<0.001*
Left lateral movement (mm)	7.46	2.06	5.31	2.24	−2.15	<0.001*

Notes: T1 = Initial evaluation; T4 = Longest follow-up; dif. = difference; SD = standard deviation; *p* = *p* value; Max. = Maximum; ns = not statistically significant; mm = millimeters.
* = statistically significant ($p < 0.05$).

($p < 0.001$); TMJ pain improved from 4.7 (± 2.8) to 0.9 (± 2.4) ($p < 0.001$); Headaches improved from 3.9 (± 3.2) to 1.4 (± 2.5) ($p < 0.003$); Jaw function improved from 4.8 (± 1.8) to 1.5 (± 1.6) ($p < 0.001$); Diet improved from 3.7 (± 2.6) to 1.4 (± 1.6) ($p < 0.001$); and Disability improved from 2.4 (± 2.0) to 0.3 (± 0.6) ($p < 0.001$) (Table 3).

Mean MIO (T1-T4) improved from 42.2 (± 9.2) to 43.5 (± 5.7) mm but was not statistically significant ($p = 0.453$). Lateral excursions decreased significantly post surgery on the right from 7.4 (± 2.4) to 4.7 (± 2.0) mm ($p < 0.001$), and left from 7.5 (± 2.1) to 5.3 (± 2.2) mm ($p < 0.001$) (Table 3).

Cephalometric presurgical changes (T2–T1)

Although there were minor changes in the cephalometric variables from initial consultation to immediate presurgery with retrusion of the mandible, none were significant (Table 4).

Cephalometric surgical changes (T3–T2)

All parameters demonstrated significant changes except for ANS-Me ($p = 0.139$) (Table 4). These changes are expected with major counterclockwise rotation of the maxillo-mandibular complex and significant decrease of the occlusal plane angle. SNB increased 5.8°, occlusal plane (SN-OP) decreased 9.1°, and mandibular plane (SNGoMe) decreased 5°. Mandibular ramus length (Ar-Go) increased 2.3 mm, mandibular corpus length (Go-Me) 8.4 mm, (Go-B) 6.2 mm, and anterior skeletal height (ANS-ME) decreased 0.9 mm (Table 4). The increase of the vertical height of the ramus (Ar-Go) is in part due to repositioning the disc over the condyle that displaces the condyle and ramus inferiorly.

Table 4. Comparison of four time intervals for Cephalometric variables.

	T1		T2		T3		T4		
Variables	mean	SD	mean	SD	mean	SD	mean	SD	T3-T2 *p* value
SNB (degrees)	73.58[a]	3.66	73.13[a]	3.75	78.96[b]	3.26	78.63[b]	2.98	<0.001*
SN - PNS/ANS (degrees)	6.58[a]	3.60	6.75[a]	3.54	0.67[b]	4.87	1.83[b]	4.55	<0.001*
SNGoMe (degrees)	43.29[a]	7.16	44.17[a]	6.71	39.17[b]	5.29	39.67[b]	5.51	<0.001*
SN–OP (degrees)	21.38[a]	5.33	21.42[a]	5.87	12.33[b]	4.90	12.21[b]	4.59	<0.001*
Ar-Go (mm)	40.06[a]	5.22	39.83[a]	5.65	42.17[b]	5.89	41.69[b]	5.64	<0.001*
Go-Me (mm)	67.46[a]	4.87	67.56[a]	6.05	75.98[b]	7.95	76.60[b]	6.88	<0.001*
Go-B (mm)	67.94[a]	3.98	67.85[a]	5.34	74.06[b]	6.57	74.69[b]	5.71	<0.001*
ANS-Me (mm)	69.35[a]	7.56	70.31[a]	7.89	69.44[b]	6.85	69.29[b]	6.79	0.139 ns

Notes: See Table 2 for cephalometric landmark definitions; T1 = Initial evaluation; T2 = Presurgery evaluation; T3 = Immediate post surgical evaluation; T4 = Longest follow-up; SD = standard deviation; $p = p$ value; ns = not statistically significant; Variables in time intervals with the same superscript letter (a or b) have no statistically significant difference between them.
* = statistically significant ($p < 0.05$).

Table 5. Comparison of variables between the time intervals T3 and T4.

	T3		T4			
Variables	average	SD	average	SD	dif.	*p*
Sup. Screw-Me (mm)	65.23	4.93	65.65	4.46	0.42	0.228 ns
Sup. Screw-B (mm)	56.90	4.18	57.60	3.60	0.71	0.100 ns
Sup. Screw-S (mm)	63.52	6.04	63.70	6.22	0.18	0.695 ns

Notes: ns = not statistically significant; SD = standard deviation; dif. = difference; Me = Menton; B = Point B; S = Sella; Sup. = Superior; $p = p$ value; mm = millimeters.
Using the superior screw as a point of reference for measurement, there were no changes in position of the mandible horizontally (jaw length) and vertically, at longest follow-up.

Cephalometric post surgical changes (T4-T3)

All parameters demonstrated very stable outcomes with no significant changes (Table 4). SNB decreased 0.3°, occlusal plane angle (SN-OP) 0.1°, and mandibular plane (SNGoMe) 0.5°. Ramus height (ArGo) decreased 0.5 mm, in part due to resolution of post surgical swelling in the TMJs. Mandibular corpus length (GoMe) increased 0.6 mm and Go-B, 0.6 mm (Table 4). Additional variables evaluated included changes related to the fixed point in the mandible (superior ramus bone screw). Assessments were measured from the screw to three structures; Menton, Point B, and Sella. Although there was evidence of some mandibular growth post surgery, there were no significant vertical and horizontal changes, indicating good positional stability of the mandible (Table 5).

Discussion

This study demonstrates that surgical management of AICR is highly predictable when using the following surgical protocol: (1) Removal of the bilaminar tissues surrounding the condyle; (2) Disc repositioning with the Mitek anchor technique (Figure 2); and (3) Maxillary and mandibular osteotomies with counterclockwise rotation of the maxillo-mandibular complex. Comparing the presurgery to longest follow-up parameters, these patients have very stable skeletal and occlusal outcomes, significant reduction in pain and headaches, and improvement of jaw function, diet, and disability. Results for disc repositioning are better if patients are treated within the first four years from onset of the disc dislocation [30]. In AICR, disc dislocation is an inclusive factor in the disease process and diagnosis. However, discs frequently become non-reducing early in the pathological process. Non-reducing discs deform and degenerate more rapidly than discs that reduce on opening, thus the importance for earlier surgical intervention.

A weakness of this study is the small sample size ($n = 24$) and relative short follow-up (mean of 30.3 months), but the addition of the subjective and objective clinical data, along with the cephalometric data, provides a more comprehensive visualization of the outcome using this specific treatment protocol compared to previous studies that evaluated only cephalometric and occlusal relation data. Larger patient population studies are necessary to further validate the outcomes presented herein.

In relation to the subjective assessment of pain, there was a significant decrease in painful symptoms (TMJ and facial pain, headache) with the treatment protocol used. The masticatory function became close to normal, and patients have reported little or almost no difficulty with chewing or constraint on the diet. Although MIO remained within normal limits post surgery, there was a decrease in lateral movements (Table 3).

All measurements of variables related to postsurgical positional stability (T3), (SNB, ArGo, GoMe and GoB) remained stable at long term (T4). The counterclockwise rotation surgically performed on the maxillo-mandibular complex remained very stable in the long term, represented by the SN-PNS/ANS, SNGoMe and SN-OP (Tables 4 and 5).

The results of this study emphasize the predictability of this treatment protocol. Post surgery changes (T4–T3)

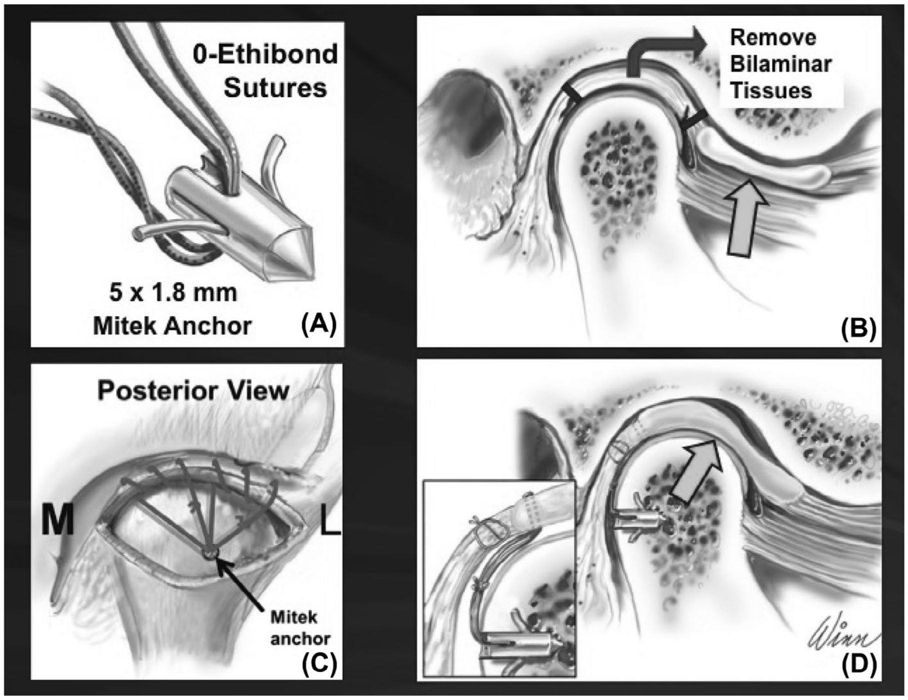

Figure 2. Mitek Anchor Technique: (A) Mitek Mini Anchor is 5 × 1.8 mm in dimension with an eyelet to support two artificial ligaments (0-Ethibond suture). (B) Bilaminar tissues are excised and disc mobilized. (C,D) The disc is passively positioned over the condyle and Mitek anchor placed in the lateral aspect of the posterior head, about 8 mm below the top of the condyle; the sutures are attached to the posterior band of the disc and secured.

demonstrate that SNB had a slight decrease in angulation (0.3°), which may be explained by immediate post surgery (T3) inter-capsular edema that resolved, allowing the condyle to position further upwards and posterior at the longest follow-up. This theory may be supported by the fact that ramus length measurement from (Ar–Go) increased 2.3 mm at surgery (T3–T2), while the physical length of the ramus was not changed. The downward displacement of the ramus was probably related to disc repositioning and edema that increases the joint space between the condyle and fossa; a parameter not evaluated in this study. The subsequent change from T4 to T3 of 0.5 mm may reflect resolution of intercapsular edema. Interestingly, the corpus length of the mandible increased slightly at Go-Me and Go-B by 0.6 mm, which may indicate some additional mandibular growth in some of the younger patients. The SNB post surgical change may have been affected by post surgical orthodontics causing a slight downward and backward rotation of the mandible also causing a slight increase in the mandibular plane angle (SN–Go–Me) of 0.50°.

Previously described are the clinical, radiographic, and MRI characteristics of patients with AICR as well as the pathophysiology and nature of the disease [1,2,17]. Patients who develop AICR are predominately teenage females, with initiation of the pathological process during their pubertal growth phase (ages 11 to 15 years), with development of HOP facial morphology, as well as skeletal and occlusal Class II relationships. These patients are often candidates for orthodontics and orthognathic surgery, even before the onset of the disease. Since AICR usually develops during pubertal growth, consequently, some patients are in orthodontic treatment at the onset of the disease. AICR will develop regardless of orthodontic or orthognathic surgical intervention. However, these procedures can increase loading and stress on the TMJ and can initiate or accelerate the rate of condylar resorption. AICR can go into remission but can be reactivated by parafunctional habits, trauma, orthodontics, orthognathic surgery, or other factors that load or stress the joint [1,2,17].

For patients with AICR, an MRI is imperative for assessment of articular disc position and condition as well as condylar evaluation and can differentiate from other TMJ pathologies that cause condylar resorption. Cone beam imaging is a helpful diagnostic tool but was not used for any of the patients in this study.

In AICR, the ligaments that normally stabilize the articular disc in position are severely degenerated with no ligament substance remaining for repair. Therefore, the use of the Mitek anchor with artificial ligaments [1,2,18–22] has significantly improved the stability of results in disc repositioning procedures, particularly in treating AICR. A Mitek anchor supports two artificial ligaments (0-Ethibond suture) threaded through the eyelet of the anchor and secured to the articular disc (Figure 2). The Mitek anchors are very stable and osseo-integrate with the bone in the condylar head [23,24].

Attempting to treat AICR cases with orthognathic surgery alone, ignoring the TMJ pathology, is a strong inducer for: (1) Further condylar resorption; (2) Redevelopment of functional and esthetic deformities; (3) Worsening TMJ symptoms and dysfunction; (4) Worsening pain; and (5) Requirements for additional surgery [22,31].

Stability studies for AICR

Previously published studies demonstrate highly predictable treatment outcomes using this surgical protocol for AICR [1,2]. Wolford and Cardenas [1], in 1999, described outcomes on 12 patients with documented active AICR (identified then as idiopathic condylar resorption, ICR); average presurgical rate of condylar resorption was 1.5 mm per year, the mandible became more retruded at point B at a rate of 2.5 mm per year, and the occlusal plane increased 2° per year. Surgical treatment followed the protocol described herein [1,2] with the mandible advanced an average of 10.9 mm (range 2 to 18 mm), and the occlusal plane angle decreased an average of −7.8° (range −5° to −12°). The post surgical follow-up average was 33.2 months with no further condylar resorption and stable occlusal and skeletal outcomes, as confirmed by clinical and cephalometric analyses. In all 12 patients, jaw function remained unchanged with no statistically significant difference in the presurgery and post surgery incisal opening (47 mm) and excursive movements (greater than 7 mm). There was a statistically significant decrease in pain.

Wolford et al. [2], in 2001, reported on 44 patients with active AICR who were divided into two groups. Group 1 (n = 10) underwent orthognathic surgery *only*, with no TMJ surgical treatment, and Group 2 (n = 34) underwent TMJ disc repositioning with the Mitek anchor technique and simultaneous orthognathic surgery. In Group 1, AICR continued in all 10 patients post-surgery, resulting in statistically significant skeletal and occlusal relapse with re-development of Class II occlusion and anterior open bite as well as continued pain. Group 2 patients all maintained stable Class I skeletal and occlusal outcomes with no statistically significant difference in any of the cephalometric measurements from immediately post surgery to longest follow-up. Group 2 had statistically significant reduction in pain and improved jaw function compared to Group 1.

The best results in the management of AICR involve early detection of the disease process and early surgery management. The earlier AICR is treated, the more likely the following will occur: (1) Elimination of condylar resorption, thus, maintaining a greater condylar dimension; (2) Less distortion and degeneration of the articular disc; and (3) Better postsurgical distribution of loading forces on the joint structures. The high predictability of treatment outcomes with this protocol for AICR substantiates that an early diagnosis and initiation of this specific treatment protocol will provide the best success functionally, occlusally, and esthetically, with elimination or significant reduction in pain, and long-term stability.

In more severe cases, where the condyle and disc are non-salvageable, condylar replacement may be necessary with either a sternoclavicular joint graft, costochondral graft, or the authors' preference, the patient-fitted TMJ Concepts total joint prostheses (TMJ Concepts Inc., Ventura, CA, USA) [32, 33].

The significance of the articular disc being in a normal stable position for stable outcomes is further supported by a study by Wolford et al. [31], in 2003, that evaluated 25 consecutive patients with jaw deformities and anteriorly displaced discs treated with orthognathic surgery *only*. All but one patient had the mandible advanced. Presurgery, 36% of the patients had pain or discomfort. At an average of 2.2 years post surgery, 84% of the patients had TMJ related pain, with a 70% increase in pain severity. The average relapse at Point B was 36% of the amount of mandibular advancement achieved at surgery. In addition, post surgery, 25% of the patients developed anterior open bites from condylar resorption. This study clearly demonstrates the problems associated with performing orthognathic surgery *only* on patients with co-existing TMJ disc dislocations.

Gonçalves et al. [22], in 2008, evaluated 72 patients who had double-jaw orthognathic surgery with counterclockwise rotation of the maxilla-mandibular complex divided into three groups. Group 1 (G1) with healthy TMJs received orthognathic surgery only; Group 2 (G2) with bilateral articular disc dislocation received articular disc repositioning with the Mitek anchor technique with concomitant orthognathic surgery; and Group 3 (G3) with bilateral articular disc dislocation received orthognathic surgery only. Average post surgical follow-up was 31 months. At surgery, the occlusal plane angle decreased significantly by −6.3° to −9.6°. The maxillomandibular complex advanced and rotated counterclockwise similarly in all three groups, with advancement at Menton of about 13 mm. Post-surgery, the occlusal plane angle increased in G3 (37% relapse), while G1 and G2 remained stable. Mandibular post-surgical changes demonstrated a significant anteroposterior relapse in G3 at Menton (28% of the mandibular advancement), while G1 and G2 remained stable. This study clearly demonstrated that maxillomandibular advancement with counterclockwise rotation of the occlusal plane is a stable procedure for patients with healthy TMJs and for patients with simultaneous TMJ disc repositioning using the Mitek anchor technique. Patients with preoperative TMJ articular disc displacement who underwent double-jaw surgery and no TMJ intervention experienced significant relapse.

Al-Moraissi and Wolford [34] recently published a meta-analysis on the effect of TMJ pathology with or without surgical management on stability of counter-clockwise rotation (CCWR) of the maxillo-mandibular complex (MMC) in orthognathic surgery. There were 12 studies with 345 patients who met the inclusion criteria. There was significant relapse of the occlusal plane, B-point, and Menton for studies with untreated TMJ disc displacement undergoing CCWR of the MMC. Studies with healthy TMJs with discs in normal position, TMJs with displaced discs repositioned with the Mitek anchor technique, and TMJs reconstructed with patient-fitted total joint prostheses were stable.

The surgical sequencing for performing TMJ and orthognathic surgery at one operation or divided into two operations (the TMJ and orthognathic procedures performed separately) is important to achieve good outcomes and includes TMJ surgery first, followed by mandibular ramus sagittal split osteotomies with rigid fixation, followed by maxillary osteotomies with rigid fixation. With the mandibular osteotomies being performed after the TMJ surgery, the mandible will be positioned into its final predetermined position regardless of the amount of mandibular displacement resulting from the TMJ surgery. Light vertical elastics (3.5 oz.) with a slight Class III vector are usually used post surgery to control the occlusion and minimize the TMJ intercapsular edema. Closely monitoring and managing the occlusion in the post surgery period, as well as controlling the parafunctional habits (e.g. clenching, bruxism), are very important to provide high quality outcomes. When end-stage TMJ pathology requires reconstruction with total joint prostheses, then the mandible can be advanced, counterclockwise rotated if indicated, and asymmetries corrected with custom-fitted total joint prostheses and fat grafts without requiring additional mandibular osteotomies [32,33,35–42].

Wolford et al. [30], in 2002, reported on 70 patients with displaced TMJ articular discs treated with the Mitek anchor technique and orthognathic surgery, and showed that presurgery, 80% of the patients had preoperative TMJ pain, but at longest follow-up, 60% had complete relief of pain, and an additional 33% had significant reduction in pain. All but one patient had stable orthognathic surgery outcomes. Using the criteria of incisal opening greater than 35 mm, stable skeletal and occlusal relationships, and significant reduction in pain, the success rate was 91%. The success rate was significantly better (95%) if the TMJ discs were repositioned surgically within the first four years of onset of the TMJ disc displacement. After four years, the progression of irreversible TMJ degenerative changes may result in a significantly lower success rate.

Conclusion

AICR is a specific condition affecting the TMJs and predominately occurs in teenage females with onset during the pubertal growth phase between the ages 11 and 15 years [1,2,17]. AICR causes articular disc anterior dislocation and mandibular condylar resorption with loss of vertical dimension and volume of the condyle, creating occlusal and musculoskeletal instability, resulting in the development of a dentofacial deformity, TMJ dysfunction, and pain [1,2,17]. Surgical management of AICR is highly predictable if performed within four years of disease onset, when using the following protocol: (1) Removal of the bilaminar tissues surrounding the condyle; (2) Disc repositioning with the Mitek anchor technique; and (3) Maxillary and mandibular osteotomies with counterclockwise rotation of the maxillo-mandibular complex. The results of this study emphasize the predictability of this treatment protocol. Additional studies with larger patient populations are necessary to further validate the results of this study.

IRB approval

Biomedical Institutional Review Board of Methodist University of Sao Paulo, Brazil (CAEE: 0005.0.214.000-11)

Conflict of interest

Neither the authors nor any members of their families have a financial arrangement or affiliation with any corporations, commercial products, or services that may be discussed in this article.

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References

[1] Wolford LM, Cardenas LE. Idiopathic condylar resorption: diagnosis, treatment protocol, and outcomes. Am J Orthod Dentofacial Orthop. 1999;116:667–677.
[2] Wolford LM. Idiopathic condylar resorption of the temporomandibular joint in teenage girls (Cheerleaders syndrome). Bayl Univ Med Cent Proc. 2001;14:246–252.
[3] Worms FW, Speidel TM, Bevis RR, et al. Post treatment stability of esthetics of orthognathic surgery. Angle Orthod. 1980;50:251–273.

[4] Kerstens HCJ, Tuinzing DB, Golding RP, et al. Condylar atrophy and osteoarthrosis after bimaxillary surgery. Oral Surg Oral Med Oral Pathol. 1990;69:274–280.
[5] Moore KE, Gooris PJJ, Stoelinga PJW. The contributing role of condylar resorption to skeletal relapse following mandibular advancement surgery: report of five cases. J Oral Maxillofac Surg. 1991;49:448–460.
[6] De Clercq CA, Neyt LF, Mommaerts MY, et al. Condylar resorption in orthognathic surgery: a retrospective study. Int J Adult Orthod Orthognath Surg. 1994;9:233–240.
[7] Arnett GW, Tamborello JA. Progressive class II development: female idiopathic condylar resorption. Oral Maxillofac Surg Clin North Am. 1990;2:699–716.
[8] Crawford JG, Stoelinga PJW, Blijdorp PA, et al. Stability after reoperation for progressive condylar resorption after orthognathic surgery: report of seven cases. J Oral Maxillofac Surg. 1994;52:460–466.
[9] Schellhas KP, Wilkes CH, Fritts HM, et al. MR of osteochondritis dissecans and avascular necrosis of the mandibular condyle. Am J Neurorad. 1989;10:3–12.
[10] Copray JCVM, Jansen HWB, Duterloo HS. Growth and growth pressure of mandibular condylar and some primary cartilages of the rat *invitro*. Am J Orthod Dentofac Orthop. 1986;90:19–28.
[11] Will LA, West RA. Factors influencing the stability of the sagittal split osteotomy for mandibular advancement. J Oral Maxillofac Surg. 1989;47:813–818.
[12] Huang CS, Ross RB. Surgical advancement of the retrognathic mandible in growing children. Am J Orthod. 1982;82:89–103.
[13] Merkx MAW, Van Damme PA. Condylar resorption after orthognathic surgery. J Cranio Maxillo Fac Surg. 1994;22:53–58.
[14] Huang YL, Pogrel MA, Kaban LB. Diagnosis and management of condylar resorption. J Oral Maxillofac Surg. 1997;55:114–119.
[15] Arnett GW, Milam SB, Gottesman L. Progressive mandibular retrusion – idiopathic condylar resorption. Part I. Amer J Orthod Dentofac Orthop. 1996;110:8–15.
[16] Arnett GW, Milam SB, Gottesman L. Progressive mandibular retrusion–idiopathic condylar resorption. Part II. Amer J Orthod Dentofac Orthop. 1996;110:117–127.
[17] Wolford LM, Galiano A. Adolescent internal condylar resorption (AICR) of the temporomandibular joint, part 1: a review of diagnosis and treatment considerations. CRANIO®. 2017; ahead of print.
[18] Wolford LM, Cottrell DA, Karras SC. Mitek mini anchor in maxillofacial surgery. In: Pelton AR, Hodgson D, Duerig T, editors. Proceeding of the First International Conference on Shape Memory and Superelastic Technologies, Asilomar Conference Center; 1994; Pacific Grove CA. MIAS. Monterey: CA, USA. p. 477–482.
[19] Mehra P, Wolford LM. Use of the Mitek anchor in temporomandibular joint disc repositioning surgery. Baylor University Medical Center Proceedings. 2001;14:22–26.
[20] Mehra P, Wolford LM. The Mitek mini anchor for TMJ disc repositioning: surgical technique and results. Int J Oral Maxillofac Surg. 2001;30:497–503.
[21] Wolford LM, Cassano DS, Gonçalves JR. Common TMJ disorders: orthodontic and surgical management. In: McNamara JA, Kapila SD, editors. Temporomandibular disorders and orofacial pain: separating controversy from consensus. Craniofacial growth series. 46, Ann Arbor, MI, USA: The University of Michigan; 2009. p. 159–198.
[22] Gonçalves JR, Cassano DS, Wolford LM, et al. Postsurgical stability of counterclockwise maxillomandibular advancement surgery: affect of articular disc repositioning. J Oral Maxillofac Surg. 2008;66:724–738.
[23] Fields RT Jr, Cardenas LE, Wolford LM. The Pull-out force of mini and micro suture anchors systems in human mandibular condyles. J Oral Maxillofac Surg. 1996;55:483–487.
[24] Fields RT Jr, Franco PF, Wolford LM. The osseointegration of Mitek mini suture anchors in the mandibular condyle. AAOMS 78th Annual Meeting and Scientific Sessions. J Oral Maxillofac Surg. 1997;55:92–93.
[25] Wolford LM, Chemello PD, Hilliard FW. Occlusal plane alteration in orthognathic surgery. J Oral Maxillofac Surg. 1993;51:730–740.
[26] Wolford LM, Chemello PD, Hilliard FW. Occlusal plane alteration in orthognathic surgery–part I: effects on function and esthetics. Am J Orthod Dentofac Orthop. 1994;106:304–316.
[27] Chemello PD, Wolford LM, Buschang PH. Occlusal plane alteration in orthognathic surgery–part II: long-term stability of results. Am J Orthod Dentofac Orthop. 1994;106:434–440.
[28] Houston WJB. The analysis of errors in orthodontic measurements. Am J Orthod. 1983;83(5):382–390.
[29] Galvão MCS, Sato JR, Coelho EC. Dahlberg formula – a novel approach for its evaluation. Dental Press J Orthod. 2012;17(1):115–124.
[30] Wolford LM, Karras S, Mehra P. Concomitant temporomandibular joint and orthognathic surgery: a preliminary report. J Oral Maxillofac Surg. 2002;60:356–362.
[31] Wolford LM, Reiche-Fischel O, Mehra P. Changes in temporomandibular joint dysfunction after orthognathic surgery. J Oral Maxillofac Surg. 2003;61:655–660.
[32] Wolford LM, Cottrell DA, Henry CH. Temporomandibular joint reconstruction of the complex patient with the Techmedica custom-made total joint prosthesis. J Oral Maxillofac Surg. 1994;52:2–10.
[33] Chung CJ, Choi YJ, Kim IS, et al. Total alloplastic temporomandibular joint reconstruction combined with orthodontic treatment in a patient with idiopathic condylar resorption. Am J Orthod Dentofac Orthop. 2011;140(3):404–417.
[34] Al-Moraissi EA, Wolford LM. Does TMJ pathology with or without surgical management affect the stability of counterclockwise rotation of the maxillo-mandibular complex in orthognathic surgery?: a systematic review and meta-analysis. J Oral Maxillofac Surg. 2016;75:805–821. DOI:10.1016/j.joms.2016.10.034.
[35] Wolford LM, Mehra P. Custom-made total joint prostheses for temporomandibular joint reconstruction. Baylor University Medical Center Proceedings. 2000;13:135–138.
[36] Wolford LM, Pitta MC, Reiche-Fischel O, et al. TMJ concepts/Techmedica custom-made TMJ total joint prosthesis: 5-year follow-up study. Int J Oral Maxillofac Surg. 2003;32:268–274.

[37] Mercuri LG, Wolford LM, Sanders B, et al. Long-term follow-up of the CAD/CAM patient fitted total temporomandibular joint reconstruction system. J Oral Maxillofac Surg. 2002;60:1440–1448.

[38] Dela Coleta KE, Wolford LM, Gonçalves JR, et al. Maxillo-mandibular counter-clockwise rotation and mandibular advancement with TMJ Concepts total joint prostheses: part I – skeletal and dental stability. Int J Oral Maxillofac Surg. 2009;38(2):126–138.

[39] Dela Coleta KE, Wolford LM, Gonçalves JR, et al. Maxillo-mandibular counter-clockwise rotation and mandibular advancement with TMJ Concepts total joint prostheses: part II – airway changes and stability. Int J Oral Maxillofac Surg. 2009;38(3):228–235. Epub 2009 Jan 9.

[40] Pinto LP, Wolford LM, Buschang PH, et al. Maxillo-mandibular counter-clockwise rotation and mandibular advancement with TMJ Concepts total joint prostheses: part III – pain and dysfunction outcomes. Int J Oral Maxillofac Surg. 2009;38(4):326–331.

[41] Wolford LM, Mercuri LG, Schneiderman ED, et al. Twenty-year follow-up study on a patient-fitted temporomandibular joint prosthesis: the Techmedica/TMJ Concepts device. J Oral Maxillofac Surg. 2015;73:952–960.

[42] Mercuri LG. A rationale for total alloplastic temporomandibular joint reconstruction in the management of idiopathic/progressive condylar resorption. J Oral Maxillofac Surg. 2007;65:1600–1609.