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Mandibular Reconstruction in Hemifacial Microsomia Using Costochondral Grafts: A Retrospective Clinical Study

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Abstract

Background: Hemifacial Microsomia (HFM) represents a profound reconstructive challenge, characterized not merely by skeletal asymmetry, but by complex, three-dimensional functional and aesthetic deficits. In growing children lacking a functional Temporomandibular Joint (TMJ), the autogenous Costochondral Graft (CCG) remains the reconstructive cornerstone due to its unique biological growth potential.

Methods: This retrospective study evaluates the clinical, functional, and aesthetic outcomes of 13 pediatric patients with severe HFM who underwent mandibular reconstruction using CCGs at Sohag University between January 2012 and December 2025.

Results: The cohort comprised 8 girls and 5 boys with a mean age of 5.2 years, presenting with Pruzansky-Kaban Type IIB (n=8) and Type III (n=5) deformities. Surgery successfully restored immediate facial symmetry in all patients. Over a mean follow-up of 6.4 years, Maximal Incisal Opening (MIO) improved significantly from a preoperative mean of 18.5 mm to 34.2 mm ($p < 0.05$). While harmonious adaptive graft growth was observed in 7 patients (53.8%), unpredictable graft overgrowth occurred in 3 patients, undergrowth in 2, and TMJ ankylosis in 1.

Conclusion: CCG reconstruction offers transformative immediate functional and aesthetic improvements for children with severe HFM, alleviating significant psychosocial distress. However, the graft's erratic biological growth trajectory demands that surgeons and family's approach this as the first stage of a longitudinal, multi-phase reconstructive journey extending through skeletal maturity.

Keywords: Hemifacial Microsomia; Costochondral Graft; Facial Asymmetry

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Introduction

Hemifacial Microsomia (HFM) is a complex, progressive congenital anomaly of the first and second branchial arches. Beyond the clinical classification of the skeletal defect - most commonly graded by the Pruzansky-Kaban system - HFM imposes a severe functional and psychosocial burden on the growing child [1]. The absence or profound hypoplasia of the mandibular ramus and Temporomandibular Joint (TMJ) in Type IIB and III deformities leads to progressive facial asymmetry, restricted mastication, potential airway compromise, and compensatory maxillary deformity [2, 3].

For these severe presentations in young children, distraction osteogenesis is often unviable due to the lack of adequate basal bone and a functional articulation. The autogenous Costochondral Graft (CCG) has therefore stood as the biological gold standard for skeletal reconstruction [4]. The CCG is unique: it provides immediate structural volume to restore posterior facial height, while its cartilaginous cap serves as an active biological engine, theoretically capable of mimicking the native condylar growth center to pace alongside the unaffected hemimandible [5].

However, clinical reality often complicates this biological theory. Over the decades, surgeons have grappled with the erratic and highly unpredictable behavior of the CCG. While some grafts integrate and grow in perfect harmony with the pediatric skeleton, others undergo premature fusion (ankylosis), resorption, or rampant pubertal overgrowth that creates a severe, iatrogenic contralateral asymmetry [6].



Figure 1: Mandibular Reconstruction with Costochondral Graft (CCG) in 5-year-old girl with severe right-sided HFM (Pruzansky-Kaban Type III) (A, B) Preoperative frontal and lateral views showing pronounced mandibular deviation, occlusal cant, and microtia. (C, D) Long-term postoperative frontal and lateral views demonstrate restored facial symmetry, levelled oral commissure, and harmonious mid-facial alignment. (E, F, G) postoperative photos showing correction of facial symmetry, maximal mouth opening and occlusal cant.

This manuscript reflects on a 13-year institutional experience at the Maxillofacial Head and Neck Surgery Unit of Sohag University. By analyzing the outcomes, growth patterns, and complications of 13 pediatric patients, this study aims to provide a grounded, clinical perspective on the true long-term utility and challenges of CCG reconstruction in severe HFM.

Patients and Methods

Study design and cohort

A retrospective review was conducted of pediatric patients surgically managed for unilateral HFM at Sohag University, Egypt, between January 2012 and December 2025. Inclusion criteria required a diagnosis of Pruzansky-Kaban Type IIB or III HFM, primary reconstruction using an autogenous CCG, and a minimum follow-up of two years. Patients with bilateral craniofacial syndromes or previous TMJ surgeries were excluded.

The cohort consisted of 13 children (8 girls and 5 boys). Ethical approval was granted by the Institutional Review Board, and detailed informed consent including extensive preoperative counseling regarding the likelihood of secondary surgeries was obtained from all parents.

Surgical protocol

All procedures were performed under general anesthesia with nasotracheal intubation.

Recipient Bed Preparation: A preauricular incision combined with a submandibular approach was used to expose the hypoplastic mandible [7]. Fibrotic bands were aggressively released to untether the skeletal remnant. Maxillomandibular Fixation (MMF) was temporarily applied to level the occlusal cant and position the mandible into its true anatomical alignment, correcting the facial midline. A conservative neocavity was prepared in the temporal bone to receive the graft.

Graft Harvest and Inset: The CCG was harvested from the right fifth, sixth, or seventh rib. Recognizing the profound risk of rampant graft overgrowth, meticulous care was taken to sharply trim the cartilaginous cap, retaining only 1 to 2 mm of cartilage. The bony strut was contoured and rigidly fixed to the lateral aspect of the decorticated mandibular ramus using pediatric 2.0-mm titanium miniplates. The cartilaginous head was seated passively in the temporal fossa, and MMF was released to confirm smooth hinge movement.

Postoperative rehabilitation

To minimize the devastating complication of TMJ ankylosis, prolonged immobilization was strictly avoided. MMF was maintained for only 1 to 2 weeks, immediately followed by an aggressive, parent-assisted active physiotherapy regimen focusing on vertical mouth opening and lateral excursions.

Results

Demographics and immediate outcomes

The demographic profile and surgical variables of the 13 patients are summarized in Table 1. The mean age at the time of surgery was 5.2 years. The surgical procedures were uniformly successful in restoring immediate posterior facial height and correcting the clinical facial asymmetry, with no instances of donor-site pneumothorax or immediate graft failure.

Table 1: Demographic and clinical characteristics of the study cohort (N = 13).

Parameter	Patient Cohort Value
Gender	Female: 8 (61.5%) Male: 5 (38.5%)
Mean Age at Surgery	5.2 years (range: 3.1–9.4 years)
Affected Side	Right: 7 (53.8%) Left: 6 (46.2%)
Pruzansky-Kaban Classification	Type IIB: 8 cases (61.5%) Type III: 5 cases (38.5%)
Follow-up Duration	Mean: 6.4 years (range: 2.0–13.8 years)

Table 2: Preoperative *vs.* postoperative functional outcomes.

Measurement	Preoperative Mean	Postoperative Mean	*p*-value
Maximal Incisal Opening (MIO)	18.5 ± 4.2 mm	34.2 ± 3.8 mm	< 0.05
Occlusal Cant Angle	12.4° ± 3.1° deviation	2.1° ± 1.2° deviation	< 0.05

Table 3: Long-term graft growth patterns & secondary complications.

Growth/ Functional Outcome	No. of Patients (N=13)	Percentage	Primary Intervention Required
Harmonious/ Adaptive Growth	7	53.8%	None; clinical observation
Unpredictable Overgrowth	3	23.1%	Secondary condyle shaving / Osteotomy
Graft Undergrowth	2	15.4%	Distraction osteogenesis (Secondary)
Ankylosis	1	7.7%	Gap arthroplasty & physiotherapy

Functional recovery

Functional rehabilitation was a primary benchmark of success. As detailed in Table 2, the mean Maximal Incisal Opening (MIO) improved dramatically from a restricted preoperative baseline of 18.5 mm to a robust 34.2 mm at final follow-up ($p < 0.05$). Concurrently, the severe occlusal cant was levelled, vastly improving masticatory efficiency and the children's ability to tolerate a normal diet.

Clinical illustrations of success

The transformative nature of the procedure in early childhood is best illustrated visually. Figure 1 demonstrates a highly representative case from our cohort, wherein rigid fixation of the CCG provided immediate and lasting facial balance, allowing the child's soft tissues to adapt to a normalized skeletal framework.

Discussion

The management of Type IIB and III hemifacial microsomia is as much a test of a surgeon's foresight as it is of their technical skill. When a child presents with a functionally absent TMJ and severe facial collapse, the immediate priority is to construct a foundation that prevents the cascading secondary deformities of the maxilla and airway [8]. In our 13-year experience, the costochondral graft has proven to be an exceptional tool for this immediate structural rescue.

The functional improvements observed in our cohort (MIO increase to 34.2 mm) align closely with international literature confirming that early CCG reconstruction successfully establishes a functional, articulating joint space [9]. Beyond the numbers, the restoration of dietary normalcy and the immediate alleviation of psychosocial distress for both the child and their parents represent the most profound human impacts of this surgery.

However, the biological unpredictability of the CCG remains the central challenge of this procedure. As outlined in Table 3, while 53.8% of our patients exhibited harmonious, adaptive graft growth, a significant proportion experienced growth anomalies.

The cartilaginous cap of the rib is highly reactive. Despite our strict adherence to retaining only 1 to 2 mm of cartilage a technique championed by Guyuron and Lasa to prevent rampant growth [6], 23.1% of our cohort (3 patients) still developed severe graft overgrowth during their pubertal growth spurts. The graft, acting independently of the facial growth matrix, can grow at an accelerated vertical vector, pushing the reconstructed chin point entirely over to the contralateral, unaffected side. The CCG has undergone unpredictable pubertal overgrowth, driving the mandible aggressively toward the unaffected right side, resulting in a severe secondary asymmetry requiring orthognathic correction.

These cases underscore a critical clinical reality: the CCG is rarely a definitive, single-stage cure. It must be viewed as an early, essential matrix that buys the child time and functional normalcy, with the explicit understanding that secondary orthognathic surgery or condylar shaving will likely be necessary upon reaching skeletal maturity [10].

Finally, our remarkably low rate of TMJ ankylosis (7.7%, or 1 case) reflects an evolution in postoperative care. Historically, prolonged MMF was used to ensure graft integration, which inadvertently promoted bony fusion. By limiting MMF to less than two weeks and initiating aggressive, parent-assisted physiotherapy, we ensured that the neocondyle healed in a state of functional movement, preserving the joint space [11].

Conclusion

Reconstructing the absent pediatric mandible with an autogenous costochondral graft is a profoundly impactful intervention, providing children with severe hemifacial microsomia the immediate gift of facial symmetry and a functional jaw. The 13-year cohort at Sohag University demonstrates that while the CCG is surgically reliable and functionally superior to non-biological alternatives, its inherent biological volatility cannot be fully tamed. Surgeons must partner closely with families, framing the CCG not as the final destination, but as the vital first step in a lifelong reconstructive journey.

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