Condylar Hyperplasia of the Temporomandibular Joint

Types, Treatment, and Surgical Implications

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KEYWORDS

• Condylar hyperplasia • Osteochondroma • Condylar tumor • Condylar hyperactivity
• Condylectomies

KEY POINTS

- Not all prognathic mandibles are caused by condylar hyperplasia (CH), only those showing accelerated, excessive mandibular growth continuing beyond the normal growth years.
- Diagnosis is made through serial radiographs, dental models, clinical evaluations, and bone scan techniques.
- The earlier the operation is done, the less pronounced the mandibular deformity.
- Identifying the specific CH pathology will provide insight into its progression if untreated and will guide the treatment plan.
- The more severe the pathology, the greater clinical asymmetry and the degree of morphologic alterations.
- The type of CH, and the presence or lack of activity will define whether condylectomies are necessary.

INTRODUCTION

Condylar hyperplasia (CH) is a progressive and pathologic overgrowth of either or both mandibular condyles. These condylar pathology can adversely affect the size and morphology of the mandible, alter the occlusion, and indirectly affect the maxilla, with the resultant development or worsening of dentofacial deformities, such as mandibular prognathism; unilateral enlargement of the condyle, neck, ramus, and body; facial asymmetry; malocclusion; and pain.[1] There are many suggested etiologies of CH, including neoplasia, trauma, infection, abnormal condylar loading,[2] hormonal influence, heredity, and aberrant growth factors.[2]

Some CH occurs more commonly within particular age ranges and genders. Identifying the specific CH pathology will provide insight to its progression if untreated and will guide the treatment plan. The type of CH, and the presence or lack of activity will determine condylectomies are necessary. The diagnosis is usually made by clinical, radiologic examinations, and bone scintigraphy.[3] Since the first description of the treatment of CH with condylectomies by Adams in 1836 and Humphry in 1856, several therapeutic options have been proposed. The treatment objective is to eliminate the pathologic processes and provide optimal functional and esthetic outcomes.[1]

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CLASSIFICATION

CH is a generic term describing conditions that create excessive growth and that can cause alterations in the bony architecture of the mandible, malocclusion, and dentofacial deformity. Several classifications have been proposed for CH. Obewegeser and Makek[4] classified CH into 3 categories: hemimandibular hyperplasia, causing asymmetry in the vertical plane; hemimandibular elongation, resulting in asymmetry in the transverse plane; and a combination of the 2 entities. Nitzan and colleagues[5] described CH as a unilateral disorder in which the pathology occurs at the head of the condyle, creating facial asymmetry in the vertical or horizontal direction or a combination of both. In 2014, Wolford, Movahed, and Perez[1] proposed a classification encompassing the various CH pathologies.

Condylar Hyperplasia Type 1

The onset of this condition usually occurs during puberty; it is an accelerated and prolonged growth aberration of the normal condylar growth mechanism, and it can occur bilaterally (CH type 1A) or unilaterally (CH type 1B). The growth vector is usually in a horizontal direction creating mandibular prognathism and is self-limiting, with growth termination usually in the early to mid 20s.

Condylar Hyperplasia Type 2

This condylar pathology, osteochondroma, is the most commonly occurring mandibular condylar tumor; it can develop at any age (although more commonly during the teen years), with a unilateral vertical overgrowth deformity of the jaws. The growth process can continue indefinitely, with progressive worsening of the facial asymmetry. One growth vector causes predominantly vertical elongation and enlargement of the condylar head and neck (CH type 2A) and the other form also has a horizontal exophytic tumor growth off of the condyle (CH type 2 B).

Condylar Hyperplasia Type 3

These are other types of benign tumors that can cause condylar enlargement such as osteoma, neurofibroma, giant cell tumor, fibrous dysplasia, chondroma, chondroblastoma, and arteriovenous malformation.

Condylar Hyperplasia Type 4

These are malignant tumors arising from the mandibular condyle that cause condylar enlargement such as chondrosarcoma, multiple myeloma, osteosarcoma, Ewing sarcoma, and metastatic lesion.

This article will use the Wolford's classification,[1] and since types 1 and 2 are the most common CH pathologies,[1,6] the following sections will address those 2 types of CH.

CONDYLAR HYPERPLASIA TYPE 1

Clinical Diagnosis

Common clinical characteristics observed in bilateral, symmetrically growing CH type 1A patients usually include (**Table 1**)[1]

- Accelerated mandibular growth
- Mandibular growth continuing beyond the normal growth years into the early to middle 20s
- Worsening class 3 skeletal and occlusal relationship
- Obtuse gonial angles
- Facial shape more triangular and tapered

Additionally, unilateral cases of CH type 1 B may have (**Fig. 1**)[1,5]

- Worsening facial and occlusal asymmetry, with the mandible progressively shifting toward the contralateral side
- Unilateral posterior cross-bite on the contralateral side
- Transverse bowing of the mandibular body on the affected side
- Transverse flattening of the mandibular body on the contralateral side
- Worsening unilateral class 3 occlusion on the ipsilateral side

A horizontal mandibular growth vector extending beyond the normal growth years will likely be CH type 1, and the growth can continue into the middle 20s until cessation. Conditions that initiate excessive accelerated mandibular growth after the pubertal growth phase (15 years of age for girls, 17–18 years of age for boys) are most often unilateral and related to CH type 2 (osteochondroma) or other types of proliferative condylar pathology.[1]

Imaging Diagnosis

Radiographic analysis will show increased length of the condylar head and neck, without a significant volumetric increase in the size of the condylar head. MRI scans will show that the articular discs are commonly thin and may be difficult to identify. Occasionally, the articular discs can be posteriorly displaced (**Fig. 2**).[1]

Table 1
Condylar hyperplasia features (types 1 and 2)

CH	Age at Onset	Clinical Findings	Imaging	Histology
Type 1A	• Pubertal growth	• Bilateral accelerated symmetric growth • Self-limiting; can grow into mid-20s • Class III occlusion; • Prognathic mandible.	• Bilateral elongated condylar head, neck, body • Normal condylar head shape • MRI: thin discs; asymmetric cases may involve contralateral disc displacement	• Normally growing condyle • May show chondrocyte proliferation during initial and active phases, with normal bone after growth ceases
Type IB	• Pubertal growth	• Unilateral accelerated asymmetric growth • Self-limiting, can grow into mid-20s • Deviated mandibular prognathism; • Ipsilateral class 3 occlusion; anterior and contralateral cross-bite	• Unilateral elongated condylar head, neck, body • Normal condylar head shape • Mandibular deviated prognathism; • MRI: thin disc; may have ipsilateral/ contralateral disc displacement	• Normally growing condyle • May show chondrocyte proliferation during initial and active phases, with normal bone after growth ceases
Type 2	• Two- thirds of cases begin in second decade	• Unilateral vertical elongation of face and jaws • Not self-limiting; can grow indefinitely • Ipsilateral posterior open bite	• Unilateral vertical enlarged condylar head, neck, ramus, body • Type 2A: enlargement without horizontal exophytic growth off condyle • Type 2B: enlargement with exophytic growth off condyle • MRI: ipsilateral disc commonly in place contralateral TMJ arthritis, displaced disc, 75% of cases	• Bony mass • Cap of fibrocartilage, hyaline cartilage, fibrous tissue of perichondrium, endochondral ossification

Adapted from Wolford LM, Movahed R, Perez, DE. A classification system for conditions causing condylar hyperplasia. J Oral Maxillofac Surg 2014;72:567–95; with permission.

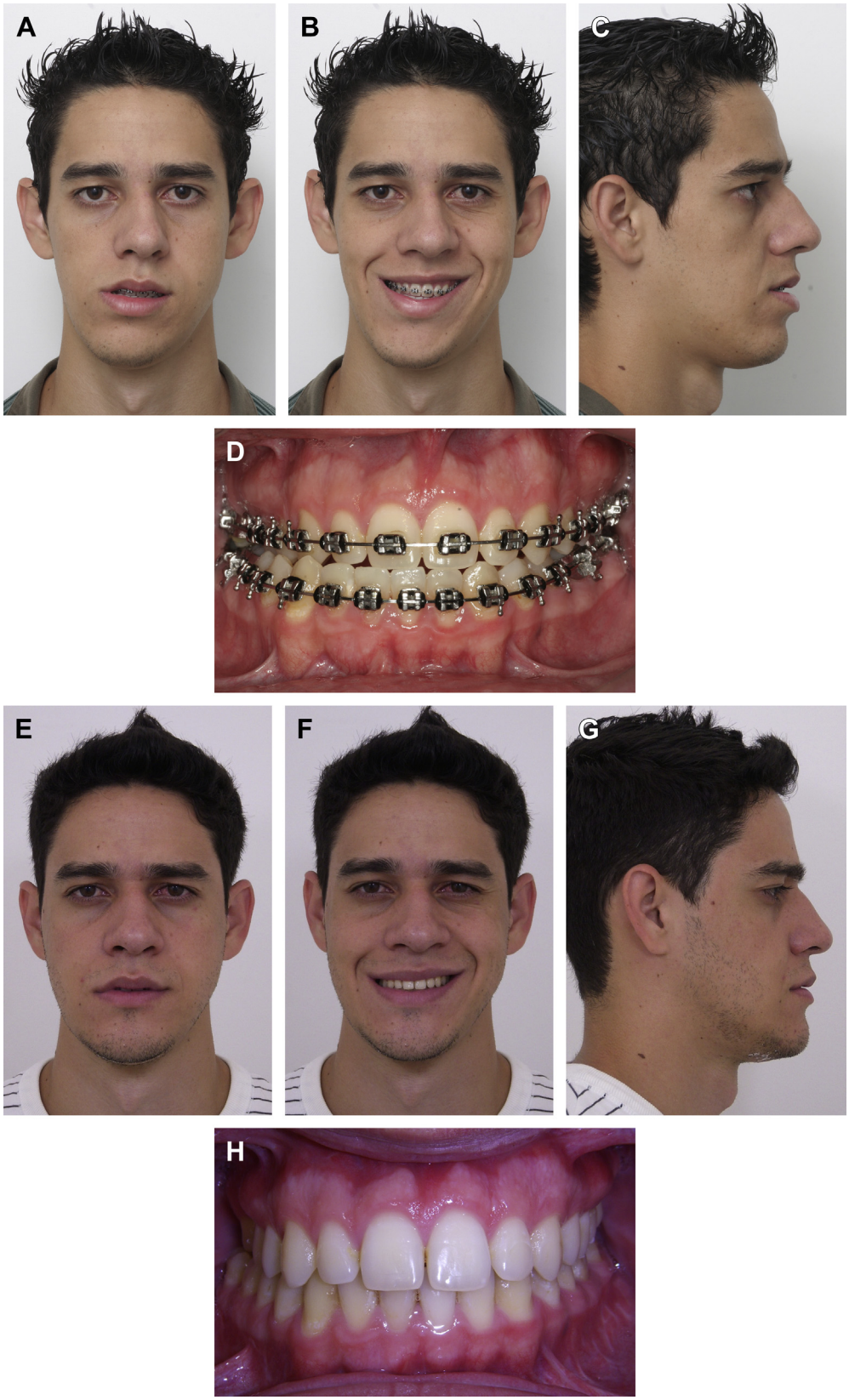

Fig. 1. (*A–D*), 19-year-old male patient with left-sided condylar hyperplasia type 1B, bilateral displaced articular discs, and mild temporomandibular joint pain. He was treated in a single surgical stage with (1) unilateral left high condylectomy; (2) bilateral disc repositioning; (3) bilateral ramus osteotomies; and (4) maxillary osteotomies. (*E–H*) At 3 years after surgery, the patient has good facial balance, stable skeletal and occlusal relations, and is pain free.

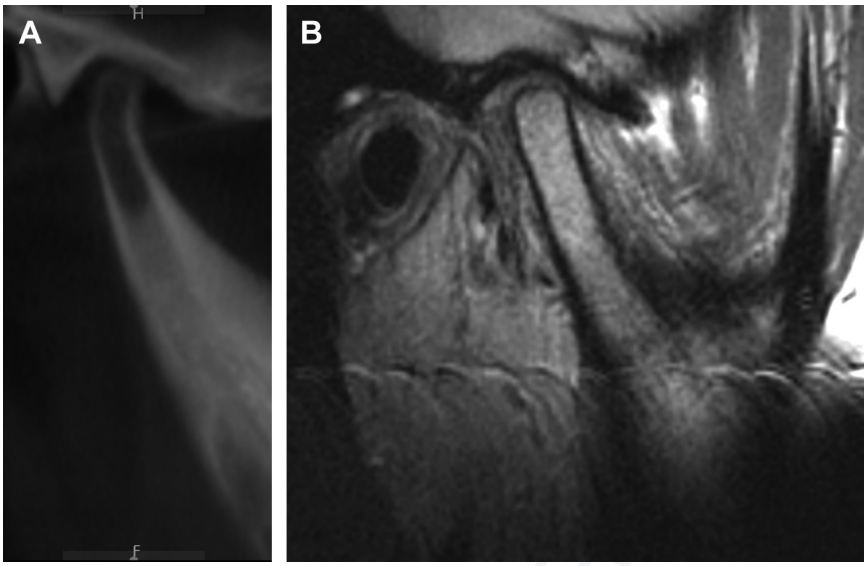

Fig. 2. (*A*) At CT scan, the CH type 1 shows an increased vertical length of the condylar head and neck. (*B*) At the MRI, the CH type 1 shows a thin disc that is difficult to identify, and can be posteriorly displaced.

Histologic Diagnosis

The histology of the affected condyle commonly resembles a normally growing condyle without any notable pathologic abnormalities. In some cases, the proliferative layer may exhibit greater thickness in some areas. The activity of the proliferative layer may regulate the rate at which the condyle and condylar neck (which is formed from the condyle by remodeling) will grow.[1,7,8]

Therapeutic Options

Not all prognathic mandibles are caused by CH, only those exhibiting accelerated, excessive mandibular growth that continues beyond the normal growth years. CH type 1 is self-limiting relative to growth; patients in their mid-20s or older will not have further jaw growth related to CH type 1, so routine orthognathic surgical procedures can usually be performed to correct the dentofacial deformity and malocclusion.[1] The treatment options for CH type 1B are similar to those for CH type 1A, in which patients with confirmed nongrowth can be treated with traditional orthognathic surgery. If active growth is confirmed, then there are 2 options for treatment (Fig. 3).[9]

Option 1

The surgical protocol for active CH type 1 consists of (Fig. 4)

- Bilateral or unilateral (depending if type 1A or 1B) high condylectomy (4–5 mm of the top of the condylar head), including the medial and lateral pole areas
- Disc repositioning, using a bone anchor
- Orthognathic surgical procedures, often requiring 2-jaw surgery to optimize the functional and esthetic outcomes Q9
- Other ancillary procedures as indicated

This protocol predictably stops mandibular growth and provides highly predictable and stable outcomes, with normal jaw function and good esthetics.[7–9]

Option 2

Surgery is delayed until growth is complete, which could be in the early to mid-20s, and then only orthognathic surgery is performed. However, the longer the abnormal growth is allowed to precede, the worse the facial deformity, asymmetry, occlusion, and dental compensations will become, in addition to warping of the mandible and ipsilateral excessive soft tissue development. This will increase the difficulties in obtaining optimal functional and esthetic results, in addition to the adverse effects on occlusion, dental compensations, mastication, speech, and psychosocial development.[1,9,10]

Surgical correction of bilateral CH can predictably be performed from the ages of 14 in girls and 16 in boys. The vector of facial growth will change to a vertical direction, because the A-P Q10 mandibular growth is stopped, but the maxillary vertical alveolar growth will continue until maturation. In unilateral cases (CH type 1B), it is recommend to delay surgery until the age of 15 for girls and 17 for boys, when most of the normal facial growth is complete. A unilateral high

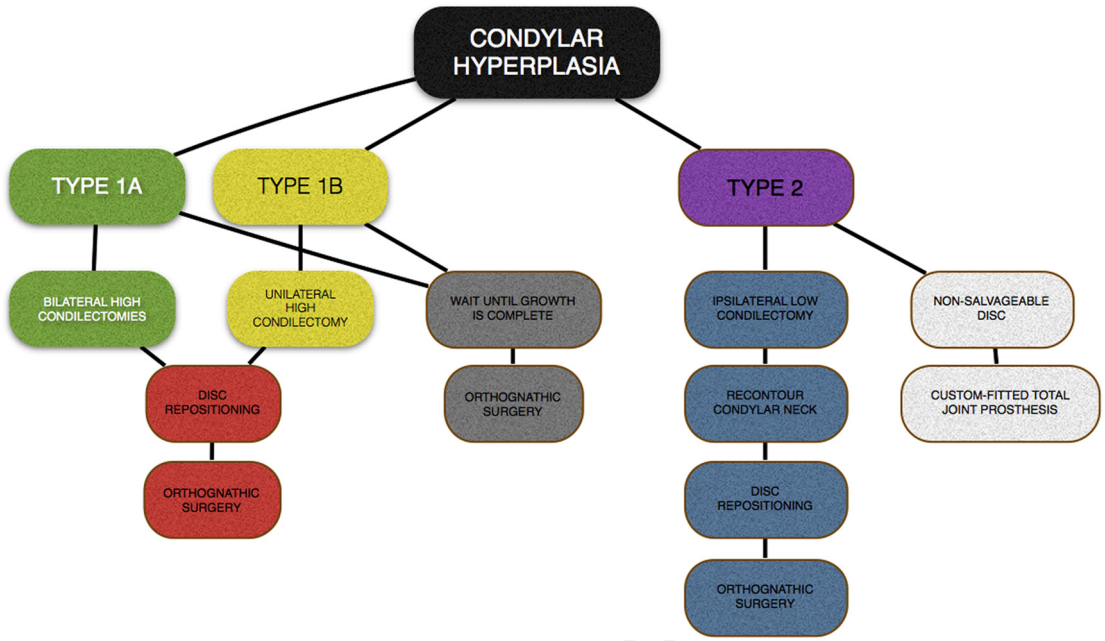

Fig. 3. Flowchart demonstrating the treatment options to manage condylar hyperplasia.

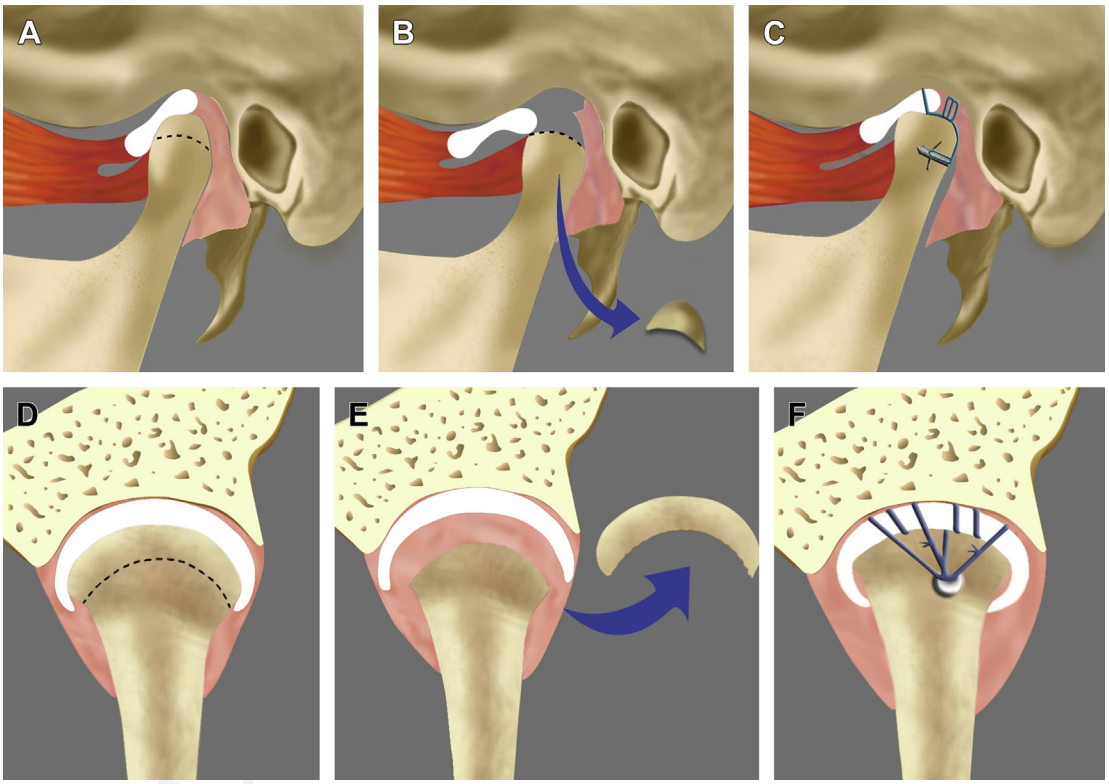

Fig. 4. (*A*) Schematic illustration shows the level of high condylectomy removing the top 4–5 mm for treatment of condylar hyperplasia type 1. (*B, C*) For CH type 1 in active growth, a high condylectomy will arrest any further anteroposterior mandibular growth. The articular disc is repositioned and stabilized on the condyle with a bone anchor. (*D, E*) Coronal view, the osteotomy must include the medial and lateral pole areas. (*F*) The anchor is placed into the posterior head 4 to 5 mm below the crown of the condyle just lateral to the midsagittal plane. The sutures are attached to the posterior aspect of the posterior band with 3 over-and-over sutures for each set of artificial ligaments (0-Ethibond); 1 set placed medial and 1 placed more lateral.

condylectomy will arrest growth on the operated side, but normal growth can continue on the contralateral side and could cause development of facial and occlusal asymmetry later if the surgery is performed at a younger age.[8]

CONDYLAR HYPERPLASIA TYPE 2

Clinical Diagnosis

CH type 2 can develop at any age, but for most cases, in the second decade (68% of cases), it occurs predominantly in female patients (76% of cases). Specific characteristics of type 2 CH include (Fig. 5)[1,6,9]

- Increased unilateral mandibular vertical height
- Increased soft tissue volume on the ipsilateral side of the face
- Low mandibular plane angle facial-type morphology
- Chin asymmetry vertically and transversely, with shifting toward the contralateral side
- Compensatory downward growth of the ipsilateral maxillary dentoalveolus
- Lateral open bite on the ipsilateral side, particularly in more rapidly growing pathology
- Labial tipping of the mandibular ipsilateral posterior teeth and lingual tipping of the contralateral posterior teeth may occur
- Transverse cant in the occlusal plane

Imaging Diagnosis

Imaging features will include the following (Figs. 6 and 7)[9]

- Mandibular asymmetry particularly in a vertical plane
- Enlarged, elongated, deformed condyle
- Increased vertical height of the ipsilateral mandibular condyle, neck, ramus, body, symphysis, and dentoalveolus
- Increased thickness of the condylar neck compared with the contralateral side
- Loss of antegonial notching with downward bowing of the inferior border on the mandible
- MRI may show a displaced articular disc on the contralateral side (76% of the cases) and associated arthritic condylar changes; the disc is commonly in position on the ipsilateral side, although it also can be displaced (see Fig. 6E)

CH type 2A indicates an enlargement of the condylar head and neck with a predominant vertical growth vector of the osteochondroma without significant exophytic tumor development (see Fig. 6A, B). There can be unevenness or lumpiness on the condyle. CH type 2B indicates exophytic tumor extensions off the condyle, usually forward and medially, with the head becoming significantly enlarged and deformed (see Fig. 6C, D).[1]

Histologic Diagnosis

Histologically, osteochondroma has been described as a cartilage-capped lesion that undergoes endochondral ossification deep in the tumor. The cartilage is often hyaline, and of varying thickness and cellularity. Chondrocytes can form rows perpendicular to the surface and overlie a zone of endochondral ossification, producing cancellous bone that blends without distinction into that of the normal underlying bone.[11] The cartilaginous islands in the subcortical bone may have direct correlation with the scintigraphic activity. The cartilage islands are mini-growth centers producing bone, causing enlargement of the condyle. As the osteochondroma enlarges, the bone-producing islands of cartilage may become further separated from each other so that in the more mature tumors, the cartilaginous islands become more difficult to identify histologically.[1]

Therapeutic Options

Treatment considerations would include (see Fig. 3 e 7)[12]

1. Low condylectomy to remove the tumor in its entirety
2. Reshape the condylar neck
3. Reposition the articular disc over the remaining condylar neck
4. An ipsilateral sagittal split osteotomy is then performed, and the disc/condylar stump complex is seated into the fossa
5. If indicated, perform orthognathic surgery to correct the maxillary and mandibular asymmetries
6. If needed, inferior border ostectomy on the involved side to reestablish vertical balance of the mandible; this may require dissection in preservation of the inferior alveolar nerve

The risk of recurrence of this benign lesion is low after surgical removal.[13]

This protocol will provide predictable and stable outcomes and optimize the functional and esthetic results. If the disc is not salvageable, a custom-fitted total joint prosthesis may be indicated to reconstruct the ipsilateral or contralateral TMJ.[9,12]

When CH type 2 is identified during the normal growth years, then surgery to resect the osteochondroma and correct the jaw's deformity (orthognathic surgery) should be deferred, if possible, until 15 years of age for girls and 17 to 18 years of age for boys, after normal jaw growth

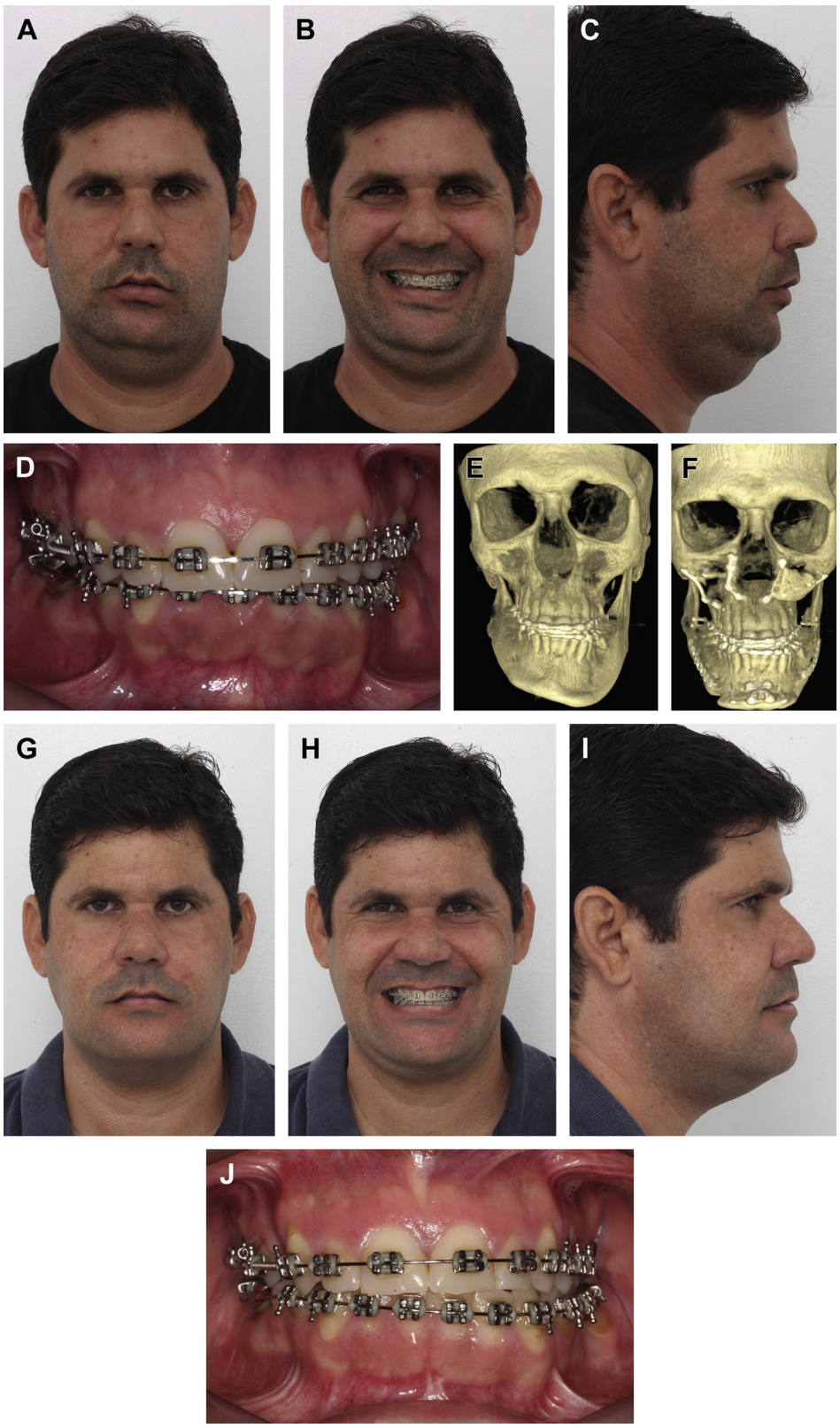

Fig. 5. (*A–D*) 34-year-old male patient presented with condylar hyperplasia type 2. He developed significant elongation of the left side of the face, retruded mandible, transverse cant in the occlusal plane. (*E, F*) 3-dimensional reconstruction before and after surgical treatment in a single stage included (1) left low condylectomy; (2) temporomandibular joint disc repositioning; (3) bilateral mandibular ramus osteotomies; (4) Le Fort I maxillary osteotomy; and (5) left inferior border ostectomy with preservation of the inferior alveolar nerve. (*G–J*) The patient 1.5 years after surgery shows good facial balance and a stable skeletal and occlusal result.

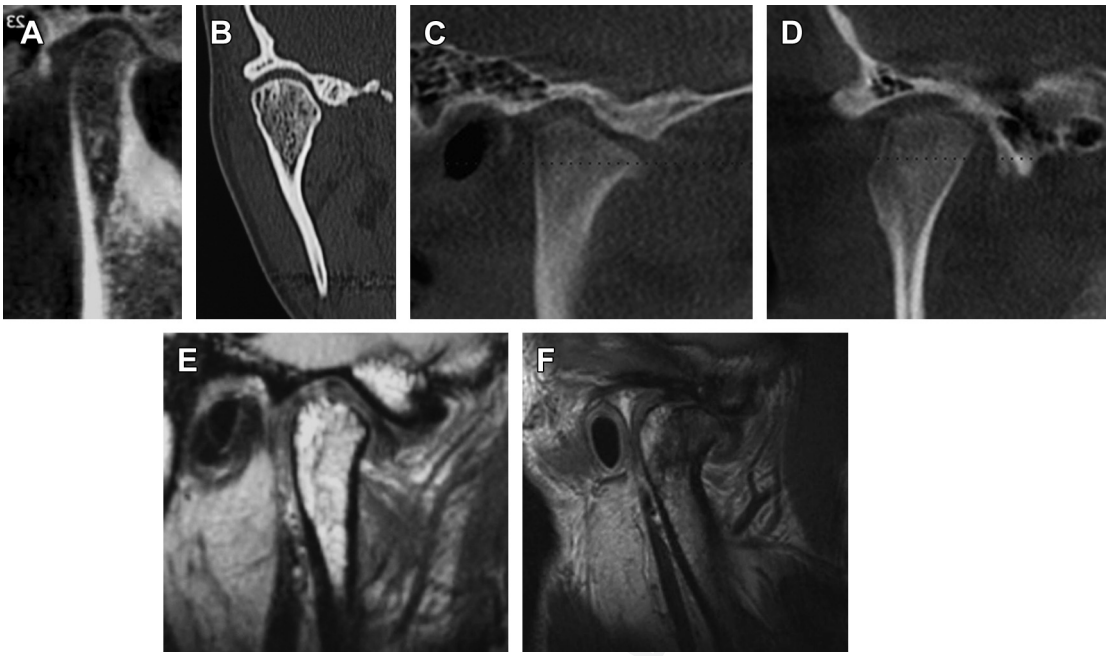

Fig. 6. At CT scan, (*A*) CH type 2A shows a larger condyle with increased vertical height of the condylar head and neck. (*B*) In the coronal view, the crown of the condyle may be more rounded than a normal condyle, (*C, D*) condylar hyperplasia type 2B have exophytic growths extending from the condylar head. At MRI, (*E*) the CH type 2A, and (*F*) CH type 2B, even with large exophytic growth development, the articular disc will commonly be in place.

is relatively complete. However, the severity of the deformity may warrant surgery at a younger age, and then an option would be to perform the unilateral condylectomy and plan for orthognathic surgery as a second stage after cessation of growth (Fig. 8). If the ipsilateral low condylectomy is performed in conjunction with orthognathic surgery when normal jaw growth is still occurring (<15 years of age in girls and <17–18 years of age in boys), then there is the risk of the contralateral condyle continuing with normal growth, shifting the mandible toward the ipsilateral side until growth cessation.[1,12]

COMPLEMENTARY TOOLS FOR DIAGNOSIS

Information regarding whether the abnormal growth is still active can be also provided by skeletal scintigraphy using technetium-99m methylene diphosphate.[13] Two frequently used scanning techniques are planar bone scanning and single-photon emission computed tomography (SPECT), both of which use the same basic technology. SPECT produces a tomographic bone scan image that may be more reliable than planar scanning.[14] Another scanning technique that can be used is positron emission tomography (PET) using a radiolabeled glucose

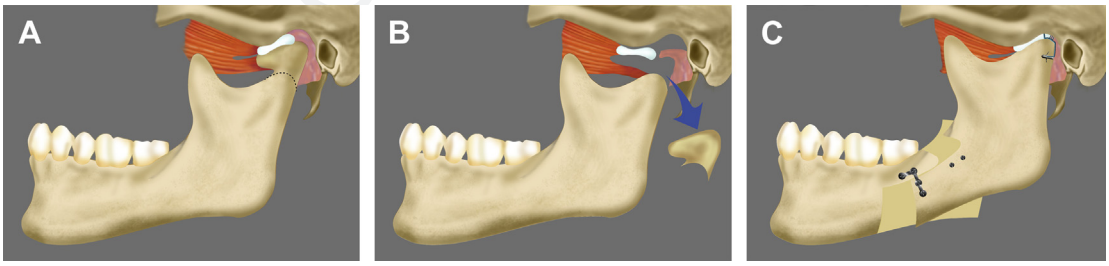

Fig. 7. (*A*) Schematic for the treatment of CH type 2 includes a low condylectomy, preserving the condylar neck as outlined to remove the osteochondroma. Commonly, but not always, osteochondromas have exophytic growths extending from the condylar head. (*B*) The condyle is removed; the condylar neck is recontoured. (*C*) The articular disc is repositioned with a bone anchor; sagittal split osteotomies are completed. Most of these cases also had an indication for maxillary osteotomies.

Fig. 8. (*A–D*) 11-year-old female patient presented with CH type 2. She developed significant elongation of the left side of the face, transverse cant in the occlusal plane. (*E*) Surgical treatment included left low condylectomy. The thickness of the cartilage on the condylar head can be seen. (*F–I*) The patient 1.5 years after surgery shows improvement on facial symmetry.

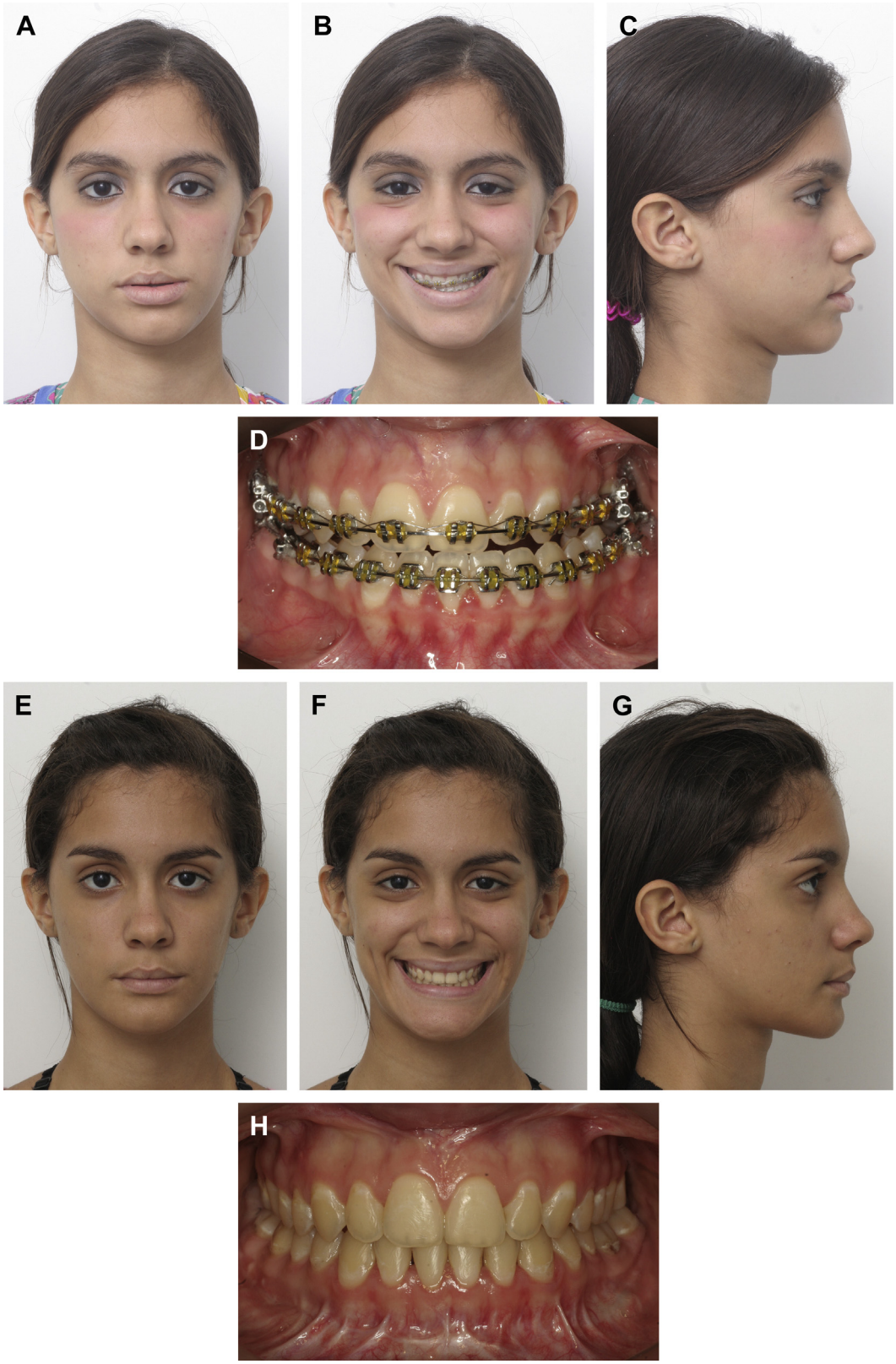

Fig. 9. (*A–D*) 18-year-old female patient with facial severe asymmetry. She was treated with: (1) bilateral ramus osteotomies; (2) maxillary osteotomies; and (3) genioplasty. No TMJ surgery (condylectomies) were performed, since no evidence of growth/activity was found. (*E–H*) at 4 years after surgery, the patient has good facial balance and stable skeletal and occlusal relations.

analog, 18F-2-fluoro-2-de- oxyglucose (FDG), as a tracer, alone or combined with CT (PET/CT). Dedicated (full ring) PET provides better spatial resolution than a conventional gamma camera and SPECT.[15] All methods might indicate increased cellular activity on the affected side.[13]

For asymmetric cases, the data indicate that an activity difference of more than 10% between the left and right condylar regions, found with bone scintigraphy, is suggestive of CH.[14]

Bone scintigraphy of the TMJs may detect active growth in the more rapidly growing CH type 1 conditions. However, in most cases, it will not be diagnostic in determining active CH type 1 growth. Healthy growing TMJs normally have some uptake at scintigraphy. The growth rate of CH type 1 is not growing at a tumorous rate, as seen in CH type 2, but only somewhat faster than the normal condylar growth rate; thus, it is usually difficult to differentiate CH type 1 from normal growth, particularly if both joints are involved.[1] In addition, the cellular growth activity is confined to a narrow band at the normal growth center resulting in low uptake, as compared to CH type 2 where there is diffuse cellular activity throughout the tumor in the condylar head. In unilateral cases, it can be more effective, especially if applied after the normal growing years, when condylar growth should have finished.[6] In CH type 2, unless the tumor is very slow growing, bone scintigraphy will usually show increased uptake, particularly in the more active tumors.

IDENTIFYING CONDYLAR HYPERPLASIA ACTIVITY

Active CH growth can usually be determined by worsening functional and esthetic changes with serial assessments (preferably at 6- to 12-month intervals) consisting of clinical evaluation (surgeon's, orthodontist's, patient's report), photograph records, dental model analysis with orthodontically trimmed models or models mounted in centric relation, and radiographic evaluation by superimposition. Radiographic evaluation includes

a. Lateral cephalometric radiographs; during pubertal growth, the normal yearly growth rate of the mandible measuring from condylion to point B is 1.6 mm for girls and 2.2 mm for boys[16]
b. Frontal cephalometric radiographs (particularly helpful in unilateral CH cases)
c. Lateral cephalometric tomograms that include the TMJ, the mandibular ramus, the body, and posterior teeth to analyze the amount of condylar growth over time for each side[1]

Bone scintigraphy or PET/CT scan are used to evaluate the metabolic activity of the bone. When all the information, photographs, study models, radiographs, and bone scans are correlated over time, some indication of the activity can be made.[17]

In evaluating the patient with suspected CH type 1, if no evidence of growth/activity is found, orthognathic surgery can be performed without condylectomy(ies) (**Fig. 9**). However, when evaluating CH type 2, if the records point to no evidence of growth/activity, a careful decision must be made whether to perform the condylectomy, since it is still a tumor. The data have not supported corrective orthognathic surgery of the maxillary and/or mandibular arches without accessing the tumor to confirm the histopathologic diagnosis.[13]

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Q5	Affiliation address is not provided for the author "Vanessa Castro", hence one of the provided affiliations has been retained for both authors. Please verify and provide the affiliation for the author "Vanessa Castro".
Q6	Please provide professional degrees (e.g., PhD, MD) for the author "Vanessa Castro".
Q7	Please verify the affiliation addresses and provide the missing information (street name and zip code for affiliation "a"). And please indicate (or confirm) which address is the preferred one for correspondence.

(*continued on next page*)

Q8	If there are any drug dosages in your article, please verify them and indicate that you have done so by initialing this query.
Q9	Please clarify whether this should be “2 jaw surgeries” instead of “2-jaw surgery”?
Q10	Please spell out A-P.
Q11	Fig. 7 was not cited in the text. Hence it has been combined with the citation of previous Fig. 6. Please verify.
Q12	Please verify what the text “e 7” indicates in Fig. 3 citation.
Q13	Please provide editor names for Ref. 16.
Q14	Please provide exact page number for Table 1 source line.
	Please check this box or indicate your approval if you have no corrections to make to the PDF file ☐

Thank you for your assistance.