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REVIEW

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An Overview of the Post-Traumatic Mandibular Bifid Condyle

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ABSTRACT

Objectives: *To review the main clinical, radiological and treatment aspects of patients with post-traumatic bifid mandibular condyles (BMC), to report a new case of BMC in a patient with history of trauma and to discuss the long term adaptive changes of the opposite condylar head.*

Methods: *An electronic search in major medical databases was accomplished. Case series and case reports, prospective or retrospective cohort studies of patients with characteristics of traumatic BMC were included. Extracted data included demographic variables, clinical aspects, imagining examinations and treatment methods performed.*

Results: *The systematic review included 60 patients with 72 post-traumatic BMC. The unilateral involvement (73.3%) and mediolateral condylar orientation (75%) were the most common types of post-traumatic BMC described. Most of the patients were symptomatic, with ankylosis (60%), limitation in mandibular movements (55%) and facial asymmetry (41.6%) being the most common clinical signs.*

Conclusion: *The presence of the post-traumatic BMC is accompanied by important clinical signs, a correct and an early evaluation being essential for an optimal treatment.*

Keywords: post-traumatic, bifid mandibular condyle, CT, MRI.

OBJECTIVES

The bifid mandibular condyle (BMC) is an unusual anomaly, which was described for the first time in 1941 (1). The review of previously published studies (2, 3) indicates that the actual prevalence of BMC ranges from 0.31% to 1.82%.

The morphological shape of post-traumatic BMC is variable; it has been described as a slight notch on the condyle head or as a complete lobulation of the condyles. Most authors considered as BMC only the cases with two separate heads, divided by a shallow groove (4).

Traumatic and developmental factors were most often incriminated in the etiology of BMC (5-7) even though the endocrinal, vascular and infectious have been also proposed (8, 9).

Congenital BMC is very frequently asymptomatic and it could be an incidental finding on a radiological examination (2, 3). Post-traumatic BMCs are usually symptomatic, clinical signs consisting in pain, facial asymmetry, limitation in mandibular movements and ankylosis (10).

The long-term functional effects of traumatic BMC on the contralateral condylar head are not very well known. It has been suggested that ar-

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thritic changes might be seen in some cases and also that osteoarthritis might develop in case of trauma (1).

Computer tomography (CT) is considered the most useful radiological examination in diagnosing BMC, even though a great number of BMC were firstly described on panoramic radiography (13-15).

Although no treatment is needed for asymptomatic BMC, an active monitoring is recommended (16). A conservative treatment, consisting in physiotherapy, occlusal splints and non-steroidal anti-inflammatory drugs, is recommended for symptomatic cases (17).

Surgical therapy could be necessary in post-traumatic BMC complicated with ankylosis (18, 19). Gap arthroplasty consists in the resection of the osseous mass between the glenoid cavity and the mandibular ramus, without interpositional material. This type of intervention creates a gap of 10-20 mm and may determine mouth deviation. Interpositional arthroplasty is characterized by a surgical gap created by resecting the osseous mass, followed by interposition of a biologic or non-biologic material (20). Joint reconstruction implies osseous mass resection and joint reconstruction, using autogenous bone grafts, or total joint prosthesis (21).

The purpose of this study is to: 1) review the main clinical, radiological and treatment aspects of patients with post-traumatic BMC; 2) report a new case of unilateral BMC in a patient with history of trauma; and 3) discuss the long term adaptive changes of the opposite condylar head. ❑

MATERIAL AND METHODS

Search strategy

An electronic search in medical databases including PubMed, Scopus and The Cochrane Library was performed until April 2020, with no restriction on the publication period. The key words used for the electronic search were "traumatic bifid condyle". The search was restricted to the clinical cases in English, including case series, case reports, prospective and retrospective cohort studies of patients. All studies performed on dry mandibles were excluded.

A subsequent manual search of all selected studies, by reading the references included in the list, was performed. The selected studies were included in an Excel document and the title and authors were screened for duplicates. The initial selection of the studies was based on reading the title and abstract, followed by a full text evaluation.

The extracted data from the studies included: author, title, year of publication, number of BMC cases. The primary outcomes of interest in the reported cases were: patients' age and sex, clinical signs, location and orientation of the BMC on the imaging examinations and the performed treatment.

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (22). ❑

RESULTS

A total number of 326 articles have been initially selected from electronic databases. After excluding duplicated and irrelevant articles, a number of 53 full-text available articles remained. Finally, after excluding BMC with non-traumatic clinical history, the systematic review included only 20 articles (15 case reports and five case series). A flow chart of the selected articles and reasons for excluding articles after full-text evaluation

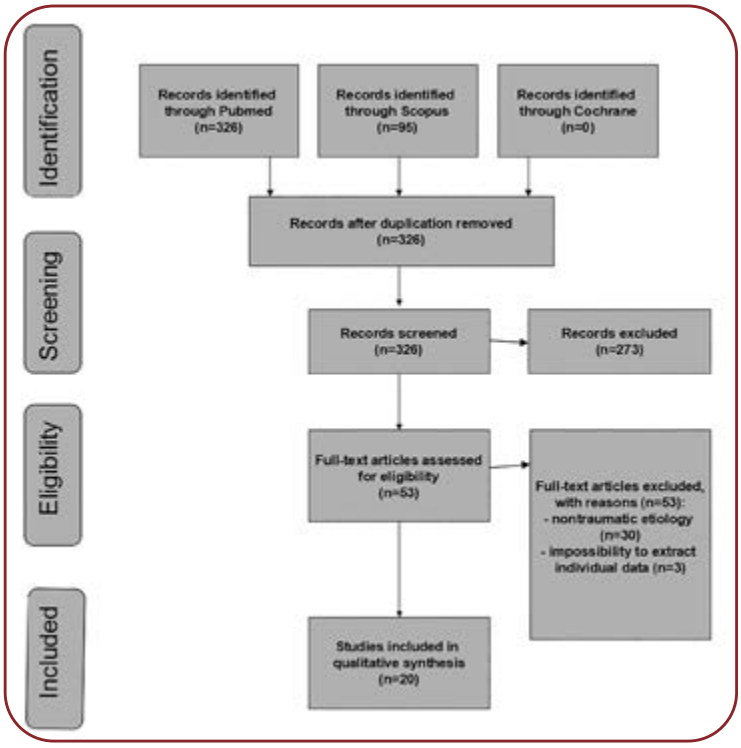

FIGURE 1. Flow chart of selected articles

are presented in Figure 1. All selected articles had a level 3 of SORT criteria. In addition, one new case report was included by the authors.

Outcomes of the main interest parameters extracted from the selected articles were organized in Table 1. A number of 60 patients with 72 post-traumatic BMC were reported. The mean age of cases was 28.3 (±15.2) years, with a wide age variation between 5 and 70 years. Male and female BMC patients were equally reported (the ratio was 1:1).

Unilateral involvement (73.3%) and mediolateral condylar orientation (75%) were the most common types of post-traumatic BMC, anteroposterior bifidity orientation being reported in 10 post-traumatic cases.

CT examination was the most used imaging method for the evaluation of post-traumatic BMC (98.3% of cases), followed by panoramic radiography (38.3%) and MRI examination (3.3%).

Clinical signs and treatment performed were summarised in Table 2, along with reporting of a new case of post-traumatic BMC. Most patients were symptomatic (93.3%) and they were referred to the clinics for ankylosis (60%), limitation in mandibular movements (55%) and facial asymmetry (41.6%).

No specific treatment besides active monitoring was applied to 10% of patients. Open temporomandibular joint (TMJ) surgery was the most used treatment option (35%) and it was performed in all cases affected by ankylosis. Physiotherapy was the only treatment recommended in 10% of patients and the remaining studies did not mention any treatment plan.

TABLE 1. Characteristics of cases included in the systematic review

Number of patients/ author	Location	Orientation	Imaging examination
3 / Sahm *et al.*[31]	2 unilateral, 1 bilateral	mediolateral	Panoramic radiography, CT
1 / To *et al.*[35]	unilateral	mediolateral	CT
1 / Antoniades *et al.*[11]	unilateral	anteroposterior	Panoramic radiography, CT
4 / Kahl *et al.*[39]	NA	NA	CT
1 / Artvinli *et al.*[25]	unilateral	mediolateral	Panoramic radiography, CT, open-close linear tomography
1 / Hersek *et al.*[15]	bilateral	mediolateral	CT, MRI
1 / De Sales *et al.*[17]	unilateral	mediolateral	Panoramic radiography, CT
1 / Daniels *et al.*[21]	unilateral	mediolateral	Panoramic radiography, CT
1 / Sales *et al.*[40]	unilateral	mediolateral	CT
12 / Balaji *et al.*[12]	9 unilateral, 3 bilateral,	mediolateral	CT
9 / Rehman *et al.*[29]	5 unilateral, 4 bilateral	7 mediolateral, 2 anteroposterior	CT
1 / Khonsari *et al.*[41]	unilateral	anteroposterior	Panoramic radiography, CT
1/ Sala Perez *et al.*[7]	unilateral	mediolateral	Panoramic radiography, CT
1 / Lopez *et al.*[28]	unilateral	anteroposterior	Panoramic radiography
4 / Li Z *et al.*[42]	unilateral	2 mediolateral, 2 anteroposterior	CT
1 / Woo *et al.*[30]	unilateral	mediolateral	CBCT
1 / Uluturk *et al.*[43]	bilateral	mediolateral	CT
12 / Guven *et al.*[44]	11 unilateral, 1 bilateral	9 mediolateral, 3 anteroposterior	Panoramic radiography, CT
1 / Jha *et al.*[26]	bilateral	mediolateral	CT
1 / Borras *et al.*[16]	unilateral	mediolateral	Panoramic radiography, CT

NA: not available information; BMC: bifid mandibular condyle; CT/CBCT: computed tomography/cone beam computed tomography; MRI: magnetic resonance imaging

TABLE 2. Clinical signs and treatment of post-traumatic BMC

Clinical signs	Asymptomatic		4
	Articular noises		3
	Articular/muscular pain		6
	Facial asymmetry		25
	Ankylosis		36
	Limitation in mandibular movements		33
	Hypoacusia		1
Treatment	Follow-up only		6
	Conservative treatment	Occlusal splints	1
		Physiotherapy	6
		NSAIDs/ Muscle relaxants	3
	Surgical treatment		21
	NA		27

BMC: bifid mandibular condyle; NSAIDs: nonsteroidal anti-inflammatory d
not available information

Case report

A 29-years old male patient with Class II malocclusion presented with TMJ noises and facial asymmetry. Clinical examination of the TMJ was conducted using a standardized protocol based on Research Diagnostic Criteria for Temporomandibular Disorders (23).

The patient had suffered a right condylar neck fracture at the age of six. He reported joint locking without pain when opening his mouth to full amplitude, which subsided following several open-close movements of the jaws.

Facial examination and the amplitude of the mandibular movements were measured using a millimeter ruler. At inspection, there was unequal vertical proportions and face asymmetry, with a right-side chin deviation. The height of the lower face (distance between the base of the nose and chin) was with 8 mm greater than the height of the mid-face (measured between the glabella to the base of the nose) and the upper face (distance between hairline and the glabella). By measuring the distance between the incisal edges of the upper and lower central incisors, the degree of maximum mandibular opening was determined, and after adding the amount of vertical incisor overlap, the recorded value was 51 mm. During opening, the mandible deviated toward the left side.

Lateral movements were measured with the patient holding the jaws in a relaxed position (physiological rest position), then moving the mandible as far as possible toward the right and left sides determining the distance from the incisal embrasure between the maxillary central incisors to the incisal embrasure of the lower incisors. The maximum lateral movement value recorded was of 9 mm on the right side, while the maximum left lateral movement value was 10 mm.

A maximum protrusion measurement was performed, requiring the movement of the mandible from the physiological rest position toward anterior, without teeth contact, obtaining a 6 mm distance between the incisal edge of maxillary central incisor to the incisal edge of the mandibular ones.

The extent of mandibular condylar movement, masticatory muscles tenderness and the presence of TMJ noises, were assessed by palpation and auscultation. Condylar movement was easily felt, no tenderness being elicited. The masticatory muscles showed no tenderness or sustained contraction, with the exception of the lateral pterygoid muscles. There was joint clicking during opening and closing. Research Diagnostic Criteria for Temporomandibular Disorders suggested a unilateral disc displacement with reduction, with intermittent locking.

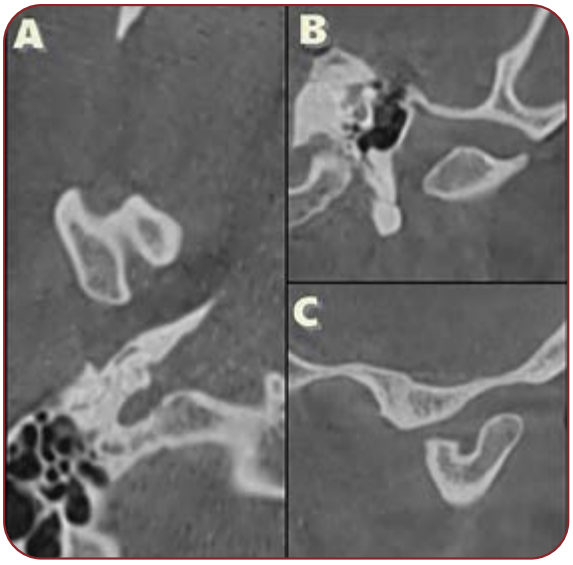

FIGURE 2. CBCT in axial (A), sagittal (B) and coronal (C) views of the right TMJ

CBCT examination was performed using a Planmeca ProMax® 3D Max unit. Coronal oblique reformatted images, on the long diameter of the right condyle, revealed two distinct heads, with lateral and medial orientation (Figure 2), the smaller, additional head being located medially. Osseous morphological alteration of the glenoid fossa and articular eminence were also noted. On the left side, TMJ arthritic changes were found (flattening and resorption of the condylar head, surface erosions and reduced joint space) (Figure 3).

For evaluating the TMJ disc and soft tissue changes, an MRI examination (3T SIGNA™ Pioneer, GE Healthcare) was performed using specific TMJ coil. The imaging protocol consisted of a T1-weighted axial spin echo image, which acted as the localizer. The scans included 3 mm sections, 15 cm field of view and a 256 x 224 matrix. The TMJs were imaged in the sagittal and coronal planes, the sagittal images being achieved along the long axis of condylar head. Bilateral anterior disc displacement, without reduction (ADDwoR), and a reduced mobility of the condyles were

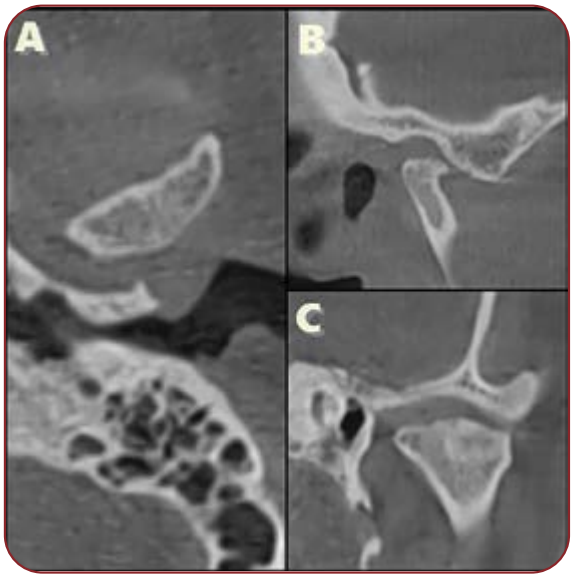

FIGURE 3. CBCT in axial (A), sagittal (B) and coronal (C) views of the left TMJ

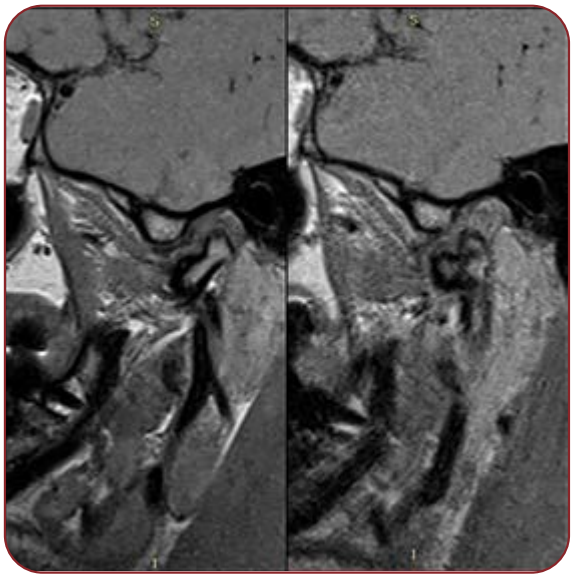

FIGURE 4. MRI in sagittal view of the right TMJ

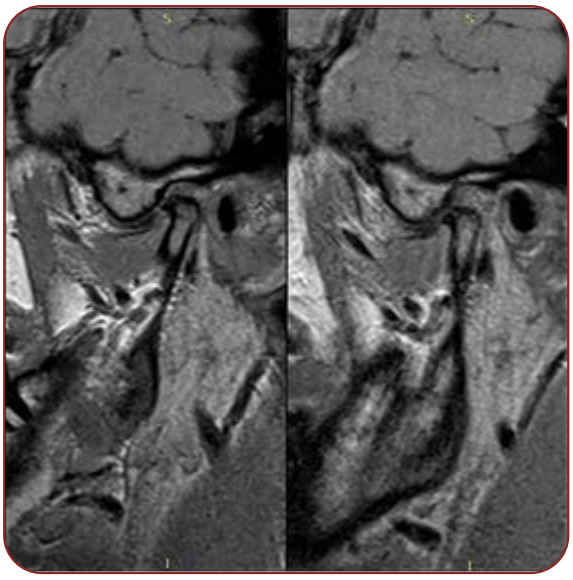

FIGURE 5. MRI in sagittal view of the left TMJ

FIGURE 6. MRI coronal view of the TMJs; the red arrow is confirming the right post-traumatic BMC

found on sagittal images (Figures 4 and 5). Coronal MRI images confirmed the right double-headed condyle and found a left medial disc displacement too (Figure 6).

Only a conservative treatment, consisting in physiotherapy and follow-up (at two and six months), was done. After two months, the clinical exam showed increased amplitude of mandibular movements (2-3 mm) and an improvement in TMJ function, with decreased frequency of joint clicking. ❑

DISCUSSION

The definition of the BMC was first introduced in 1941, as a condylar split or groove of inconstant depth (1). Later, in 1998, it was suggested that the condylar split could range from a shallow groove to the formation of two condylar heads, mediolaterally or anteroposteriorly-oriented (24). Supernumerary heads, like trifid (11, 25, 26) and tetrafid (27) condyles have also been reported.

Post-traumatic BMC could be a result of accidental condylar fractures, application of forceps during birth and surgical condylectomies (21, 28, 29). This theory is supported by the fact that, after a condylar neck fracture, an antero-medial displacement of the condyle occurs due to the lateral pterygoid muscle activity. Then, a new condylar head develops by metaplasia, in a correct anatomical position, while the displaced head is partially resorbed (30). In such cases, only the posterior condylar head would be functional (28).

It is important to highlight the role of the lateral pterygoid muscle in the formation of the BMC (6). If the muscle activity is acceptable and the remodeling capacity of the fractured condylar head is insufficient, the formation of a BMC is only a matter of time (31). Other factors to consider are the vector of the fractured condylar head and its relationship with the lateral pterygoid muscle force, which may influence the orientation of the post-traumatic BMC (30).

Bilateral post-traumatic BMC are uncommon (32). This fact is in agreement with the results of the present review, the unilateral BMC being four times more frequent. This could be explained by the traumatic etiology and by the fact that almost 60% of all subcondylar mandibular fractures are unilateral (33, 34). Although the male/female ratio is 1.25:1, no predilection for any age group has been observed for this disorder.

An important fact to consider is the orientation of the BMC, which could indicate the possible etiological factors involved. Some researchers suggested that mediolateral condyle orientation was associated to a non-traumatic etiology, while anteroposterior position could be related to trauma (6). Even so, mediolateral BMC with a history of trauma, have also been described (11, 12, 29). In the present research, a high prevalence of mediolateral condylar orientation was seen in traumatic BMC. Reddy et al found that 55.5% of BMC cases with an anteroposterior orientation, and 44.7% of those with a mediolateral position, had a history of trauma (33). However, a study published in 2011 (17) demonstrated that the great majority of cases had a mediolateral position, independently from history or trauma or not.

Morphological variations of post-traumatic BMC are also influenced by the extent of trauma. A shallow groove in the middle of a double-headed condyle is often observed in vertically fractured condylar heads, while the Y-shaped condylar heads are found in cases of severe degree of trauma (30). Another morphological issue to discuss is the symmetry of the BMC. This fact could also indicate the possible etiology involved, an asymmetric appearance of the double-headed condyle being more frequent associated with facial trauma.

In the case presented, the patient suffered mandibular trauma at age of six. Although facial trauma is common in childhood, condylar neck fracture plays an important role in the final outcome. The BMC symptomatology, appearance and orientation, together with the involved traumatic factor point to a traumatic etiology of the right BMC.

Panoramic radiography plays a limited role in diagnosing the BMC due to poor visualization of the TMJ anatomical structures and to its degree of magnification (7). However, some studies showed that the BMC with an anteroposterior orientation could be diagnosed using a panoramic radiography, in contrast to the mediolateral orientation BMC, where the condylar heads overlapped (21).

According to the current study results, CT/CBCT represents the modality of choice in diagnosing BMC, making optimal the evaluation of morphological aspects like the condyle shape and size, orientation of condylar angle, joint position, depth of glenoid fossa, and also helping in performing the differential diagnosis with tumors and

degenerative bony lesions. Furthermore, as in all TMJ entities, it is useful to evaluate the position and condition of the articular disc, by using an MRI exam. The case presented in the current research had underwent CBCT and MRI examination combined, for a complete TMJ assessment, in the idea that a combined use of these techniques significantly improves the BMC diagnosis and treatment planning.

As for traumatic BMC symptoms, the present review showed that most cases were symptomatic. These results are confirmed by the recent study of Borrás-Ferreres et al, which is reporting a high percentage of symptomatic BMC cases (84.1%) (16). Symptoms seem to be influenced by the lesion type, extent of articular structures damage, presence of hemarthrosis and age (6). TMJ ankylosis, referring to the formation of bony or fibrous adhesions in the joint, with consecutive deformation of the articular surfaces, restricts the joint movements. The association between ankylosis and post-traumatic BMC was reported as frequent, in 60% of cases, being the most prevalent clinical sign observed. The second most frequently reported sign of traumatic BMC, in over 45%, represented the limitation in mandibular movements. This clinical sign can be determined by a variety of factors such as disc displacements without reduction, muscle disorders or TMJ osteoarthritis (35). Our case showed reduced maximum values of mouth opening, protrusion and lateral movements, which could be explained by the presence of a bilateral ADDwoR.

In the present case report, CBCT showed a left condyle with arthritic changes such as flattening and condylar head resorption, surface erosions and a reduced joint space. These important osseous modifications in a young adult could represent the end point of a long standing TMJ dysfunction, an entity characterized by an abnormal relationship between the disc and the articular surfaces, in our case a bilateral ADDwoR. The possible etiology of the ADDwoR could represent the presence of the dentofacial deformity (36), accompanied by right-sided post-traumatic BMC. These arthritic modifications emphasize the importance of traumatic BMC early detection, evaluation and treatment planning.

The optimal treatment of BMC depends on the clinical picture. In asymptomatic cases, only an active monitoring is required. For mildly symptomatic cases, a conservative treatment is generally indicated, such as physiotherapy, occlusal splints and non-steroidal anti-inflammatory drugs. In more severe cases, where ankylosis develops, surgical intervention is demanded (37).

The case presented here had multiple diagnosis, including right-sided BMC, TMJ dysfunction and severe Class II malocclusion. Given that BMC was asymptomatic, the treatment plan concerned the last two diagnoses. Consequently, the initial treatment plan consisted in occlusal splint, followed by mandatory orthognathic surgery. The main goals of this protocol were to help in the reduction of TMJ dysfunction and to correct the Class II malocclusion as well as facial asymmetry. The patient refused surgery due to personal reasons. Eventually, physiotherapy with an active follow-up was performed. Muscle relaxants were not necessary, the patient not complaining of muscular or articular pain. Monitoring at two and six months showed an improvement in joint function. The patient is still under monitoring, the next appointment being scheduled over another six months. ❑

CONCLUSION

Recognition of the traumatic etiological factor is essential, the presence of post-traumatic BMC being accompanied by important clinical signs such as ankylosis and limitation in mandibular movements, with a clear impact on the patient's quality of life. The clinical picture, along with the evolution of BMC functionality, guides the optimal approach of the therapeutic decision. In addition, CBCT/CT and MRI should be considered as a valuable diagnostic combined tool in post-traumatic BMC. ❑

Conflicts of interest: none declared.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: obtained from the participant included in this study.

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