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REVIEW

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Degenerative bony changes in the temporal component of the temporomandibular joint – review of the literature

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Abstract

Temporomandibular joint (TMJ) changes are quite frequent in adults, but not all changes are degenerative. A high prevalence of bone alterations in the TMJs was reported by different research groups. Disturbed remodeling of bony articulating structures occurs because of overloading masticatory forces or because the mechanical loading in the area out-weighs the adaptive capacity of the TMJ structures. Although most of the degenerative TMJ alterations are identified at the level of the condylar process, a complete evaluation of the degenerative modifications encountered in the temporal TMJ region should not be forgotten as they are important for a comprehensive assessment and further management of the clinical situation. Several research groups have described osseous remodeling in the temporal component of the TMJ. Evidence is scarce for degenerative modifications at the level of the articular eminence and thickening of the roof of the glenoid fossa has been associated with osteoarthritis.

Keywords: temporomandibular joint, temporomandibular disorders, degenerative temporomandibular changes, osteoarthritis, osteoarthrosis, temporal bone.

Introduction

The term "temporomandibular disorders" (TMDs) generally refers to afflictions of the masticatory muscles, of the temporomandibular joint (TMJ) or its associated structures, accompanied by some symptoms like myalgia, arthralgia, dysfunction, crepitation, cephalalgia, otalgia, dizziness or even tinnitus [1–6]. Degenerative joint disease (DJD) is a common intra-articular TMD defined by TMJ articular tissue degradation and bony modifications at the level of the condyle and/or articular eminence (AE) of the temporal bone [7].

The temporal component of the TMJ is formed by the glenoid fossa (situated in the inferior part of the squamous region of the temporal bone) and its anterior limit – the AE [8].

The anatomic parts of the temporal component of the TMJ can be observed on routine dental radiographic (Figure 1, A–D) or on TMJ cone-beam computed tomography (CBCT) examinations (Figure 2).

It was classically established that bone remodeling occurs in regions exposed to high masticatory loads and for the TMJ these areas are the temporal eminence and the condylar process [9]. The AE of the temporal bone is the supero-anterior area of the mandibular fossa, on which the condyle travels during mandibular movements [10, 11]. Therefore, it would be normal to suspect or to look for degenerative changes at the level of the temporal component of the TMJ.

It is well known that the progressive joint remodeling of the TMJ leads to bone changes in the mandibular fossa, commonly found in osteoarthritis (OA) [12–15]. However, many research groups have written that the TMJ osseous degenerative features were more frequently encountered in the condyle rather than at the level of the AE or articular fossa [16–23]. Nevertheless, a complex understanding of TMJ degenerative bony modifications is essential for a

correct diagnosis and management of the TMD [21, 24].

Alterations in the AE or at the roof of the glenoid fossa (RGF) are also important observations in the diagnostic imaging of the TMJ [25]. Although most of the degenerative TMJ changes are identified at the level of the condylar process, a complete evaluation of the degenerative modifications encountered in the temporal TMJ region should not be forgotten as they are important for a comprehensive assessment and further management of the case.

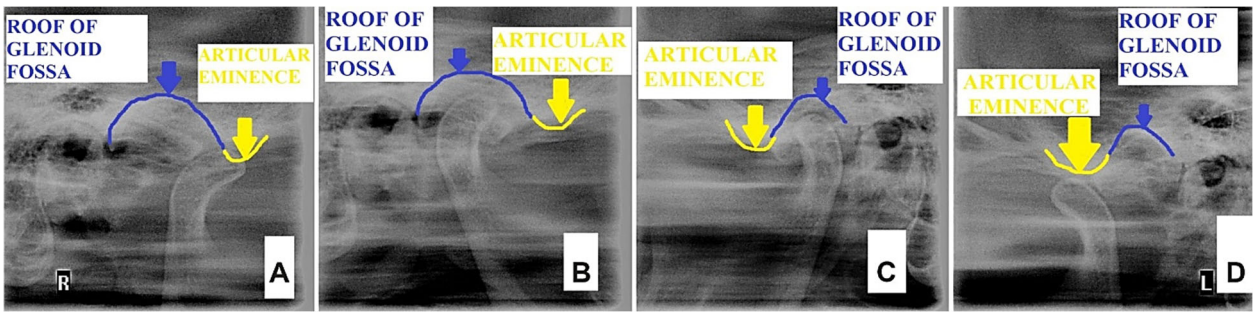

Figure 1 – ***Visualization of the temporal components of the TMJ on radiographic examinations (plain radiography): (A and C) Sagittal view of the TMJ area in the open mouth; (B and D) Closed mouth position. L: Left; R: Right; TMJ: Temporomandibular joint.***

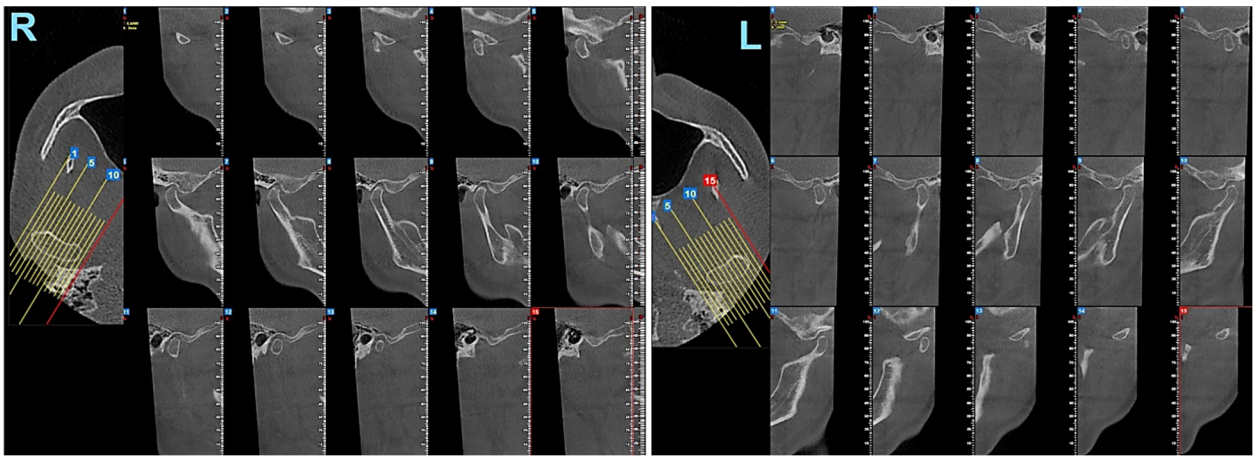

Figure 2 – ***CBCT analysis in the TMJ region: sagittal oblique CBCT of the right (R) and left (L) TMJs. CBCT: Cone-beam computed tomography; TMJ: Temporomandibular joint.***

Aim

The aim of this study was to conduct a literature review on the type and occurrence of degenerative changes in the temporal part of the TMJ: in the AE and at the level of the RGF.

Materials and Methods

References were collected from the *Clarivate Analytics/ISI Thomson Web of Knowledge*, *PubMed*, and *Google Scholar* databases. The exact search words were "degenerative temporomandibular changes" and temporal bone" or "osteoarthritis" or "osteoarthrosis" and "temporomandibular joint" or "articular eminence" or "roof of the glenoid fossa". The abstracts and titles of the identified articles were manually screened by the same authors. Article duplicates were eliminated, as well as the papers with no full-text availability and the ones that were written in other languages than English. Conference papers were excluded. The time frame of the research ranged from March to December 2021.

The inclusion criteria were: (*i*) papers published in a peer-reviewed scientific journal, (*ii*) available in full text, (*iii*) containing the following words in different combinations: "degenerative temporomandibular changes", "temporal bone", "osteoarthritis", "osteoarthrosis", "temporomandibular joint", "articular eminence", "roof of the glenoid fossa", (*iv*) case reports, experimental studies, reviews studies, letters to the editors.

The exclusion criteria were: (*i*) full text not available, (*ii*) conference papers, (*iii*) posters and theses.

The titles and abstracts of the retrieved papers were screened manually by two investigators and the articles that did not meet the inclusion criteria were removed. When the two authors did not agree on the inclusion criteria, a third author was requested to reach a decision. Another screening of the references was performed by a third author. The corresponding author carried out a manual selection on the reference list of the selected papers with the aim of adding other relevant studies to the analysis. At the end, the corresponding author completed a final check of all the included papers. The selected papers were analyzed in full-text version.

Finally, a total of 76 publications were identified and selected: 64 articles, seven reviews, two letters to the editor, one case report and three books. The comprehensive analysis is based on references with a wide publication time frame (1979–2021), containing mostly papers which appeared in the last decade.

DJD of the TMJ

The two subclasses of DJD of the TMJ are osteoarthrosis and OA [7], but sometimes there might be a confusion

between the two DJD in the dental literature. OA is the most common form of arthritis of the TMJ [26], described by synovial tissue chronic inflammation, progressive degradation of the cartilage and remodeling of the subchondral bone [27]. TMJ osteoarthrosis consists also in progressive alteration of the cartilaginous surface, synovial membrane, and bone [28].

However, the term arthrosis emphasizes the reduction of the cartilage resulting in consequent alterations at the bone level [29]. Earlier articles describe OA as an inflammatory condition within the joint that results from a degenerative condition and osteoarthrosis as a degenerative disorder of the joint with abnormal joint form and structure [9, 30].

In other papers, 'osteoarthritis' was depicted as a low-inflammatory arthritic disorder, generated by a wide variety of factors, either inflammatory or not [29, 31], while TMJ degenerative alterations similar to those seen in OA, caused by any low-inflammatory/non-inflammatory arthritic afflictions were defined as osteoarthrosis [31]. However, as the basic etiology, pathology and even treatment are similar, osteoarthrosis and OA are quite frequently confused with one another or even sometimes used as synonyms in the dental TMJ literature [29, 31].

Degenerative bony changes in the TMJ

TMJ changes are quite frequent in adults, but not all changes are degenerative. A high prevalence of bone alterations in the TMJs was reported by different research groups. TMJ osseous modifications were described in 71% of the patients evaluated by a radiologist in Brazil during an entire year [21].

In addition, a 2012 study on 117 asymptomatic participants also showed that 100 (42.7%) TMJs displayed some visible remodeling in the condyle and articular fossa/AE complex [16]. Furthermore, a paper examining TMD elderly individuals encountered bony modifications in 70% of TMJs [19]. However, the presence of bony modifications is not equal to degenerative changes and the modifications should be analyzed considering the clinical context.

TMJ degenerative joint changes can be associated with pain, but other symptoms could be countered (joint function impairment, ankylosis, reduced facial height) or patients might even be asymptomatic [16, 32–34]. Of uttermost importance is the fact that DJD diagnosis should be formulated corroborating patient's history with clinical examination, while imaging analysis is considered the reference standard for a correct diagnosis [7]. CBCT is considered the standard imaging modality for assessing degenerative bone changes of the TMJ [15, 21, 35–37]. Recently, automated detection of TMJ OA from sagittal CBCT images based on artificial intelligence was made possible and may be used to help in the diagnosis process [38].

However, the delimitation between adaptive joint changes and degenerative ones is not always quite clear [9]. Imaging observations should always be interpreted regarding the clinical context also considering the fact that there is also an ambiguous relationship between osseous TMJ morphology and degenerative bone disease [39–41]. Thus, modifications discovered on imaging analysis are not always correlated with patients' signs and symptoms [8]. For example, flattening or cortical sclerosis may indicate normal variation, ageing, remodeling or can be an intermediate stage leading to DJD [7].

Etiology of degenerative joint changes in the temporomandibular region

Etiology of degenerative joint changes in the temporomandibular region is quite complex, controversial and, perhaps, multifactorial [32, 39–41]. Tanaka *et al*. (2008) [32] considered that it is not very clear why, when exposed to similar factors, some TMJs degenerate, while others don't. Also, although degenerative TMJ changes were more frequently associated with skeletal jaw discrepancies, wide variations were reported in cases with relatively similar malocclusions [16]. TMJ degenerative changes could be multifactorial and might be caused by a wide variety of possible factors: genetic factors [42], gender, dietary loading [43], tooth loss, tooth attrition, occlusal disturbances, TMJ overloading, congenital abnormality (congenital condyle dysplasia), inflammation [44], trauma, ageing [15], bruxism, unilateral chewing, and internal derangement [23, 28, 29, 45–48].

Quite interestingly, a recent study on 100 TMD patients encountered low bone quality in TMD patients, but bone quality could not be correlated with degenerative bone modifications [49]. The condyle–articular disc–AE complex adapts to forces in the TMJ region [50]. Naturally, the mechanical loading generated during TMJ function is distributed to the condyle and glenoid fossa leading to remodeling of joint's components as an essential adaptation biological response [17, 34, 51]. Therefore, disturbed remodeling of bony articulating structures happens as a failure to adapt appropriately to the mechanical loading in the area, as well as/or because of an increased or persistent overloading functions [17, 32, 52, 53]. Thus, dysfunctional remodeling leads to degenerative changes in the TMJ [34].

Degenerative bony changes in the temporomandibular region and dentofacial morphology

The influence of the changes in craniofacial morphology on the TMJ degenerative mechanism is not quite understood [54]. Some studies argued that there might be a connection between degenerative TMJ changes and dentofacial morphology. Degenerative changes of the TMJ were more frequently associated with skeletal jaw discrepancies, especially Class II skeletal and dental relationship [16].

Recently, observations on orthodontic patients with no complaint for any disease concluded that only a small percentage of the TMJs exhibited no symptoms of OA: 14 out of 210 TMJs [55]. Sagittal skeletal relationships have a major influence on the position of the condylar process and on some bony parts of the temporal component of the TMJ, more specifically the inclination and height of the AE [56]. Furthermore, a 2016 systematic review suggested that degenerative disorders could be often found in Class II profiles and hyperdivergent growth patterns [3]. The hypothesis of an association between TMJ OA/osteoarthrosis and dentofacial morphology was also discussed, as smaller and more posteriorly rotated mandibles were observed in Japanese females with TMJ OA/osteoarthrosis as compared to the control asymptomatic Japanese females [57]. Sagittal skeletal patterns as the Class II anteroposterior maxillomandibular relationship

may predispose to diseases or complications [11, 58]. Nevertheless, a 2019 analysis on CBCT images of 213 asymptomatic participants concluded that the prevalence of degenerative TMJ changes observed in the condyle or the articular fossa/AE did not vary in patients of different skeletal patterns [4].

The idea that dental occlusion plays a role in the occurrence of TMD has been very popular and supported for a long time [59]; the absence of posterior teeth also contributes to TMD [60]. After teeth loss, the mandibular condyles follow an almost horizontal trajectory in the protrusive and lateral movements, pressing through the disc on the AE, which will undergo certain resorptions responsible for the onset of TMD. Atrophic mandibular modifications also emerge, the shape of the mandibular condyles' changes by progressive or regressive remodeling, and so does the trajectory of the mandibular canal [61–63].

However, a significant detail is that all the participants in the study by Walewski *et al*. (2019) [4] were reported to be asymptomatic and further research it is needed to investigate if there is a correlation between symptomatic degenerative TMJ changes, DJD and dentofacial morphology.

Degenerative changes in the temporal component of the TMJ

Several research groups have described osseous remodeling in the temporal component of the TMJ. A CBCT analysis on 319 patients reported only a small number of bone modifications in the temporal part of the TMJ: bone changes at the level of the AE were observed in only five cases, modifications both in the condyle and AE were found in 27 patients and five patients presented alterations of the AE and glenoid cavity [21].

Another investigation on 71 patients with imaging characteristics of degenerative arthritis encountered sclerosis of the mandibular fossa in 48% of the cases, while erosion and resorption of the mandibular fossa were associated with only 7% and 1% of the 142 TMJs [15]. Furthermore, a 2015 study on 76 OA patients found a single joint with articular fossa sclerosis, while flattening and pneumatization of the AE were each noticed in five (4.3%) TMJs [23]. Interestingly, no erosion or resorption of the articular fossa were perceived in any of the 117 joints [23]. In 2012, a CBCT research on the prevalence of TMJ OA in asymptomatic patients with dentofacial anomalies did not discover any detectable erosion in the articular fossa/AE complex [16].

Articular surface flattening of the AE/articular fossa complex were detected in nine out of 56 Class II joints, eight of 88 Class III TMJs and only one from 90 Class I TMJs [16]. Subcortical sclerosis in the AE/articular fossa complex was noticed in two Class II joints, one Class I and a single Class III TMJ [16]. Also, a 2015 evaluation on 30 TMJs of elderly patients remarked alterations in the TMJ temporal bony part in a small percent of cases: 10% in the condylar fossa (sclerosis was encountered in two TMJs and subchondral cyst in a single TMJ) and 6.6% in the AE (erosion in one joint and subchondral cysts in two TMJs) [19]. An examination of magnetic resonance imaging (MRI) scans of 74 symptomatic patients with at least one sign or symptom of TMD reported AE with erosion signs in 13 out of 148 TMJs, but no osseous modifications were observed at the level of glenoid fossa of the temporal bone [22].

Table 1 summarizes the main studies regarding the type and occurrence of degenerative changes at the level of the mandibular fossa and AE.

Table 1 – ***Occurrence of degenerative changes in the temporal component of the TMJ as described by different studies***

Study	Year	Method	Total No. of patients	Patients' distribution	Age (No. of cases)	No. of TMJs	Type of patients	Bony modifications observed in the temporal component of the TMJ	No. of TMJs with temporal modifications	Percent of TMJs with temporal component alterations
[21]	2012	CBCT	319 patients	78.26% (250) females 21.63% (69) males	10–29 years (5) 30–39 years (93) 40–49 years (62) 50–59 years (46) 60–69 years (38) 70–79 years (16) 80–89 years (12)	638	TMJ clinical symptoms or signs	AE	5 TMJs	1%
								AE + condyle	27 TMJs	7%
								AE + glenoid cavity	5 TMJs	1%
[15]	2009	CBCT	71 patients	84.5% (60) females	48.09 years mean age	142	TMJ degenerative arthritis	MF:		
								▪ sclerosis	68 TMJs	48%
				15.5% (11) males	48.18 years mean age			▪ erosion	10 TMJs	7%
								▪ resorption	2 TMJs	1%
[23]	2015	CBTC	76 patients	85.5% (65) females 14.5% (11) males	30.75 years mean age	117	OA	AF: sclerosis	1 TMJ	0.9%
								AE: flattening	5 TMJs	4.3%
[16]	2012	CBCT	117 patients	45 Class I	23.5 years mean age	90 Class I	Asymptomatic patients + Dentofacial anomalies	AE/AF:		
								▪ articular surfaces flattening	1/90 Class I	1.11%
				28 Class II	20.3 years mean age	56 Class II			9/56 Class II	16.07%
									8/88 Class III	9.09%
								▪ subcortical sclerosis	1 Class I	1.11%
				44 Class III	21.3 years mean age	88 Class III			2 Class II	3.57%
									1 Class III	1.13%

Study	Year	Method	Total No. of patients	Patients' distribution	Age (No. of cases)	No. of TMJs	Type of patients	Bony modifications observed in the temporal component of the TMJ	No. of TMJs with temporal modifications	Percent of TMJs with temporal component alterations
[19]	2015	CT Multislice helical CT	15 patients	66.66% (10) females 33.33% (5) males	63.06 years mean age	30	TMD at least on one side, generalized OA, age >50 years	CF (10%):		
								▪ sclerosis	3 TMJs	10%
								▪ subchondral cyst	1 TMJ	3.33%
								AE (6.6%):		
								▪ erosion	1 TMJ	3.33%
								▪ subchondral cyst	2 TMJs	6.66%
[22]	2012	MRI	74 patients	68.9% (51) females	40.4 years mean age	148	Symptomatic patients + At least one sign/symptom of TMD	AE: erosion	13 TMJs	8.78%
				31.1% (23) males	35.9 years mean age					

AE: Articular eminence; AF: Articular fossa; CBCT: Cone-beam computed tomography; CF: Condylar fossa; CT: Computed tomography; MF: Mandibular fossa; MRI: Magnetic resonance imaging; OA: Osteoarthritis; TMD: Temporomandibular disorder; TMJ: Temporomandibular joint.

Degenerative changes at the level of the AE of the temporal bone

A degenerative process happening at the level of the AE leads to modifications of the ipsilateral AE slope [64] and consequently the articular eminence inclination (AEI) is decreased [65]. Numerous research groups observed that TMD, dysfunctions or osseous changes encountered in the AE or in the condyle were associated with reduced AEI [65–68]. A CBCT analysis on 52 TMJ dysfunction patients and 41 control patients revealed that AEI was steeper in healthy control patients than in patients with TMJ dysfunction [67]. It was also shown that AEI had significantly reduced values on the side with unilateral condylar bone change [69]. Moreover, more severe condyle bony alterations were associated with smaller AEI [50]. However, other research groups found that AEI values did not correlate with bony modifications in the condyle [63, 70]. Nevertheless, the results in the study of Sa *et al*. (2017) [68] suggested a possible explanation. Although no major differences were observed between AEI values and condyles with or without degenerative bone disease, when the bony alterations in the condyle were reported to be more severe (two or more pathological modifications) the mean AEI was decreased. Thus, it seems that only major bony pathologies (two or more bone disease) in the condyle might cause the AEI values to diminish [68].

Interestingly enough, in patients with chewing side preferences, the AEI of the preferred chewing side was higher than the AEI value in the unpreferred side [71]. However, the forces generated during mastication might be quite variable. The masticatory efficacy is quite different in dentate and edentulous subjects, or even between edentulous patients wearing dentures with adhesives and those wearing dentures without dental adhesive [72].

Also, it was stated that attrition causes OA changes with resulting AE flattening [73]. Though, Magnusson *et al*. (2008) [47] reported no statistically significant association between major attrition and the severity of TMJ degenerative modifications.

Of note is also that degenerative modifications secondary to progressive internal derangement of the TMJ lead to reduced AE angulation [74]. Still, another study found no significant differences between disc displacement and normal disc position concerning AEI values [50]. Furthermore, Gil *et al*. (2012) [22] associated osseous alterations in the posterior part of the AE with the position of the articular disc, whereas bony modifications in the anterior AE were not associated with disc position.

Degenerative changes at the level of the RGF

Modifications at the level of the glenoid fossa can be produced by a wide variety of factors [60]. Several papers stated that the RGF appears to be influenced by degenerative bony changes in the TMJ (Table 2) [25, 75, 76].

Significantly higher RGF thickness was observed in TMJs with condylar bone change [77], degenerative joint changes [25] or OA characteristics [75, 76]. Sagittal condylar morphology, but not coronal condyle morphology seems to impact the RGF thickness [8, 74]. Ilgüy *et al*. (2014) [8] described the thickest RGF values in patients with condylar osteophyte OA, while Tsuruta *et al*. (2003) [77] reported significantly greater RGF thickness in condylar erosion cases. However, another paper concluded that RGF thickness was not correlated with condylar erosion [76]. Still, the presence of OA features in the TMJs, such as osteophyte, sclerosis, pseudocyst, and flattening did seem to influence the thickness of RGF [76].

The lowest RGF thickness was encountered in asymptomatic Class I patients [56]. Besides, RGF thickness may not be affected in the beginning of the OA modifications [76]. Of note, in the study by Derwich *et al*. no statistically significant differences concerning the glenoid fossa were found between control patients and TMJs with two or more OA modifications [55].

Study limitations

Small differences regarding the classification as degenerative bone changes have been encountered in the medical literature. For example, there are authors who do not consider the articular surface flattening as OA change if there is no alteration at the level of the condyle [55]. Most of the imaging analysis assessed in the included papers were based on CBCT interpretations, but we have also included publications reporting data obtained with the help of helical computed tomography (CT) [76] or MRI [25]. Interestingly, Kay *et al*. (2011) [25] emphasized that minimum RGF thickness was greater on MRI than on CBCT.

Table 2 – ***Relationship of the RGF thickness with the condylar bone changes as described by different studies***

Study	Year	Method	Total No. of patients	Sex ratio	Age	Type of patients	Total No. of TMJs	No. of TMJs with bony changes	RGF thickness in TMJs with bone changes
[8]	2014	CBCT	105 patients	61.9% (65) females 38.9% (40) males	47.47 years mean age (18–80 years)	Asymptomatic patients	210	Not specified	Increased RGF thickness in TMJs with condylar osteophyte OA
[76]	2003	Helical CT	37 (41) patients	65.85% (27) females 34.14% (14) males	22.3 years mean age (14–33 years)	Orthognathic surgery patients + TMD	74	50 TMJs with bilateral condylar bone change	Increased RGF thickness in TMJs with condylar erosion (18 TMJs)
[75]	2020	CBCT MRI	68 patients	91.17% (62) females 8.82% (6) males	42.3 years mean age (18–81 years)	Normal disc status or Anterior disc displacement with reduction or Anterior disc displacement without reduction	128	88 TMJs with OA	*Not correlated with condylar erosion *Influenced by osteophyte, sclerosis, pseudocyst, flattening

CBCT: Cone-beam computed tomography; CT: Computed tomography; MRI: Magnetic resonance imaging; OA: Osteoarthritis; RGF: Roof of the glenoid fossa; TMJ: Temporomandibular joint.

Conclusions

TMJ changes are quite frequent in adults, but not all changes are degenerative. Disturbed remodeling of bony articulating structures happens when there is an imbalance between the mechanical loading and the adaptive capacity of the TMJ, as well as/or because of an increased or persistent functional overload. Although most of the degenerative TMJ alterations are identified at the level of the condylar process, a complete evaluation of the degenerative modifications encountered in the temporal TMJ region should not be forgotten as they are important for a comprehensive assessment and further management of the case. Several research groups have described osseous remodeling in the temporal component of the TMJ. Evidence is scarce for degenerative modifications at the level of the AE and thickening of the RGF has been associated with OA.

Conflict of interests

The authors declare no conflict of interests.

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