

Signs, symptoms and "changes" indicating transition in Temporomandibular Joint Internal Derangements: A comparison study by subgroups.

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Abstract:

Introduction: Internal derangements of the temporomandibular joints constitute terms used to describe anatomical and functional alterations in the joint disc and adjacent anatomic structures. Not all stages of such disorders have been completely described and there may be "transitions" from one stage to the other.

Goal: Describe signs, symptoms and "changes" indicating transitional stages in subgroups presenting with internal derangements of the temporomandibular joint.

Methods: Retrospective evaluation of clinical records from subjects with bilateral TMJ capsulitis (n=30), TMJ retrodiskal pain (n=30), TMJ disk-attachment pain (n=32), TMJ arthralgia (n=23), and TMJ osteoarthritis (n=20). Clinical examination, palpation of joint and muscles, self-report, comprehensive questionnaires, criteria for craniomandibular disorders, bruxism and internal derangements of the TMJ were used to gather data about signs, symptoms and "changes" indicating potential transition from one stage of temporomandibular internal derangements to another. Data from evaluation were used to diagnose internal derangements in every subject and then were stored for future research. In a second step, signs, symptoms and "changes" were evaluated and subjects were allocated to subgroups with bilateral capsulitis, retrodiskal pain, disk-attachment pain, arthralgia and osteoarthritis of the temporomandibular joint. Data were analyzed using Kruskal-Wallis and Dunn' statistics, Chi-squared for independence and trends.

Outcome: Subjects presenting with signs and symptoms of arthralgia and osteoarthritis were generally older than those with early and intermediate stages of temporomandibular joint internal derangements: Bilateral capsulitis versus bilateral arthralgia ($p < 0,01$); bilateral capsulitis versus bilateral osteoarthritis ($p < 0,001$); bilateral retrodiskal pain versus bilateral osteoarthritis ($p < 0,01$); bilateral disk-attachment pain versus bilateral arthralgia ($p < 0,05$); bilateral disk-attachment pain versus bilateral osteoarthritis ($p < 0,01$); Bilateral osteoarthritis versus Controls ($p < 0,01$). Most common transitional signs, symptoms or "changes" in different stages of temporomandibular internal derangements were as follows. Bilateral capsulitis: simple clicking, bilateral click, unilateral reciprocal click, and pain more intense in one joint; bilateral retrodiskal pain: severer pain in one joint, unilateral or bilateral reciprocal click and occasional transient locking; bilateral disk-attachment pain: severer unilateral pain, less frequent and less intense joint noise, and crepitus "like" joint noise; bilateral arthralgia: reciprocal click, occasional transient locking, pain described as sharp/shooting and occasional crepitus; bilateral osteoarthritis: reciprocal crepitus, pain described as burning, clicking and crepitus occurring simultaneously, double crepitus occurring on opening or closing, periods of locking and less severe pain. Means in signs, symptoms or changes indicating potential transition from one stage to the other were bilateral capsulitis (0,86); bilateral retrodiskal pain (0,8); bilateral disk-attachment pain (0,8); bilateral arthralgia (1,78), bilateral OA (0,75) and Controls (0,36). Bilateral arthralgia demonstrated higher and statistically significant differences when signs, symptoms and "changes" indicating transition were compared with other internal derangements of the temporomandibular joint: Kruskal-Wallis statistics ($p < 0,0001$): bilateral capsulitis versus bilateral arthralgia ($p < 0,01$); bilateral retrodiskal pain versus bilateral arthralgia ($p < 0,01$); bilateral disk-attachment pain versus bilateral arthralgia ($p < 0,01$); bilateral arthralgia versus bilateral osteoarthritis ($p < 0,01$); bilateral arthralgia versus controls ($p < 0,001$). Frequencies of joint noises were about 40% in bilateral capsulitis, 70% in bilateral retrodiskal pain, 90,6% in those with bilateral disk-attachment pain, 60,9% in those with bilateral arthralgia

and 100% in those with bilateral osteoarthritis. Chi-squared for independence ($p < 0,0001$) and Chi-squared for trends ($p < 0,0001$), demonstrated that the subgroups were independent and that the frequency of joint noises increased from the early to the most advanced stages of temporomandibular joint internal derangements. In the early stages of internal derangement of the temporomandibular joint, simple and reciprocal clicking predominated, the intermediate stage was characterized by reciprocal clicking whereas reciprocal clicking and crepitus were characteristics of arthralgia and osteoarthritis.

Conclusion: All stages of temporomandibular joint internal derangements were characterized by some type of joint noise; most subjects with internal derangements presented with some sign, symptom or change, indicating that there were potential transitions from one stage to the other. Finally, arthralgia was the stage of internal joint derangement with most frequent signs, symptoms or changes indicating transition. The highest frequency of joint noises was found in the group with osteoarthritis of the temporomandibular joint.

Keywords: Temporomandibular Joints. Internal Derangements. Capsulitis, Retrodiskal Pain. Disk-attachment pain. Arthralgia. Osteoarthritis.

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I. Introduction

Craniomandibular Disorders (CMDs) is a collective term used in Medicine and Dentistry to describe many signs and symptoms of pain and dysfunction occurring mainly in the masticatory structures, namely, chewing muscles, temporomandibular joints (TMJs) and adjacent musculoskeletal structures (for instance, tendons and ligaments) of the stomatognathic system^[1]. Common signs and symptoms in CMDs subjects include a complaint of pain, impaired jaw movements, different types of joint noises, tenderness to palpation of the masticatory muscles and TMJs and headache of musculoskeletal origin^[2]. In CMDs patients, cervical pain is a common complaint as there is a close functional and anatomical association between the masticatory and cervical structures^[3].

Internal derangements of the TMJ (TMJs-IDs) are defined as abnormalities in shape and position of the joint disk and anatomical and biomechanical relationships with the mandibular condyle, mandibular fossa and articular eminence^[4]. TMJ-IDs represent a biomechanical dysfunction in which there is a failure of the intra-articular tissues associated with the loss of structure and function and/or with other external events or agents, including repetitive trauma from parafunctional behaviors including bruxing behavior (BB)^[5]. The hallmarks of TMJ-IDs are the abnormal position, shape, displacement and inflammation of the joint disk. In TMJ-IDs, disk-displacement is usually classified as disk displacement with (DDWR) or without reduction (DDWoR) as most disorders occurring in the TMJs depend on the status of the joint disc. DDWR is usually associated with a simple or reciprocal clicking^[4]. Signs and symptoms of TMJ-IDs may vary in severity from a mild condition with no or minimal symptoms to severe disorders with substantial degree of pain and dysfunction^[6]. Even though there are excellent classifications of TMJ-IDs with enormous clinical usefulness, the clinician must bear in mind that not all TMJ-IDs fit and/or are included in those systems of classifications^[6]. Signs, symptom and characteristics that do not fit into a specific internal derangement disorder have led the astute clinician or researcher to study borderline signs or symptoms and or disorders that can be included in a new disorder so as to illuminate and probably to modify a given classification system.

Because there is paucity of studies about sign and symptoms indicating transition in subjects with TMJ-IDs, the current investigation was designed to:

1. Describe some signs, symptoms, or changes indicating transitions from one stage of TMJ-ID to the other;
2. Evaluate most common signs or symptoms observed in each particular stage;
3. Assess the frequency and type of joint noises in each particular stage of TMJ-IDs;
4. Clinically characterize TM arthralgia as an independent stage of TMJ-IDs.

II. Material and Methods

Sample

Subjects presenting with CMDs and BB were comprehensively and consecutively evaluated over a period of 10 years in an Orofacial Pain facility at UNIRG University School of Dentistry, Gurupi-TO, Brazil.. History of the chief complaint, digital and gentle palpation for the TMJs and masticatory muscles, biomechanical tests for some TMJ-IDs, evaluation of CMDs signs and symptoms, self-reported questionnaires, evaluation of the type of headache, self-report and clinical intraoral examination were used to gather information about CMDs, BB and TMJs-IDs. No physical damage, fear or anxiety were caused during clinical examination, palpation and gathering data with the use of questionnaires. Subjects signed a formal consent allowing the researcher to use their data for future research. Then, their clinical records were stored in a database for future assessment. From January through May 2020, the clinical records of all those

demonstrating signs and symptoms of bilateral capsulitis (Bil CAP, n=30), bilateral retrodiskal pain (Bil RP, n=30), bilateral disk-attachment pain (Bil DAP, n=32), bilateral arthralgia (Bil ART, n=23), and bilateral TMJ osteoarthritis (Bil OA, n=20) were retrieved and evaluated in the search for signs and symptoms or "changes" indicating transition from one stage of TMJ-IDs to the other in each subgroup diagnosed with TMJs-IDs. All subjects allocated to each specific group presented for initial interview with widely accepted signs and symptoms of CMDs and BB. Controls (n=60) were those referred in the same period of time for initial consultation that on comprehensive evaluation did not present signs and symptoms of CMDs. Some had signs and symptoms of mild BB. Thus, 135 subjects with CMDs and TMJ-IDs and 60 Controls no CMDs and no TMJ-IDs were included in the current study.

Criteria for CMDs: A complaint of pain in the masticatory muscles and/or TMJs, presence of joint noises (self-reported and on palpation of the TMJs), tenderness to palpation of joint and masticatory muscles, restriction of jaw movements, pain during jaw movements.

Criteria for the diagnosis and inclusion of a subgroup with CMDs and bilateral capsulitis (Bil CAP): Pain on gentle digital palpation of the joint capsule externally and anteriorly to the tragus during jaw opening and closing, pain on border jaw opening, pain that ceased immediately on closing the mouth, pain on moving the mandible laterally to the opposite site to purposely stretch the joint capsule, absence of more advanced TMJ-IDs, for instance, retrodiskal pain and or disk-attachment pain (DAP).

Criteria for the diagnosis and inclusion of a subgroup with bilateral retrodiskal pain (Bil RP): Pain when clenching the teeth in the maximal intercuspal position, pain when manipulating the mandible in the centric relation position, pain when the patient was instructed to move the mandible to the affected side, the pain induced by clenching the teeth in the intercuspal position ceases immediately when the patient was instructed to clench the teeth against cotton rolls placed over the posterior teeth, absence of a more advanced TMJ-IDs.

Criteria in the diagnosis and inclusion of a subgroup with bilateral disk-attachment pain (Bil DAP): Intermittent period of locking, progressive decrease in jaw opening, reciprocal clicking, and pain described as shooting or sharp.

Criteria in the diagnosis and inclusion of a subgroup with CMDs and bilateral arthralgia (Bil ART): A long history of TMJ-IDs, pain described as burning, joint noises: simple click, reciprocal click and/or ill-defined crepitus.

Criteria in the diagnosis and inclusion of a subgroup with bilateral TMJ osteoarthritis (Bil OA): Patient is in the fifth or sixth decade of life, bilateral crepitus, patient's report of signs and symptoms indicating previous stages of TMJ-ID, for instance, a burning or shooting/sharp description of pain.

Inclusion criteria for the control subgroup: Absence of signs and symptoms of CMDs, presence of mild, moderate or no BB.

Criteria for signs, symptoms or "changes" of transition in Bil CAP: Simple or reciprocal unilateral or bilateral click, severer unilateral pain

Criteria for signs symptoms or "changes" in Bil RP: Unilateral severer pain, unilateral or bilateral reciprocal click, early and occasional episodes of locking.

Criteria for signs, symptoms or "changes" in Bil DAP : Unilateral severer pain, less frequent joint noises, occasional crepitus "type" noise.

Criteria for signs, symptoms or "changes" in Bil ART: Reciprocal click, occasional locking, pain described as shooting, intense and sharp, occasional crepitus, and crepitus "like" clicks.

Criteria for signs, symptoms or "changes" in Bil OA: Reciprocal crepitus, pain described as burning (occasional), simultaneous click and crepitus, less severe pain.

Criteria for signs, symptoms or "changes" in the control subgroup: Simple or reciprocal click, click occurring more frequently. No complaint of muscle or joint disorders.

Exclusion criteria for experimental and control subgroups: Severe psychological or psychiatric disorders, severe cognitive disorders, difficulties to respond properly to questionnaires, presence of any epilepsy disorder including Parkinson's disease, motor disorders.

III. Statistical Analysis

Kruskal-Wallis and Dunn's statistics, Chi-squared for independence and trends were used to analyze data.

IV. Outcome

This investigation evaluated subgroups of individuals with CMDs, BB and bilateral capsulitis (Bil-CAP=30); CMDs, BB and bilateral retrodiskal pain (Bil RP=30); CMDs, BB and bilateral disk-attachment pain (Bil DAP=32); CMDs, BB and bilateral arthralgia (Bil ART=23), CMDs, BB and bilateral osteoarthritis of the TMJs (Bil OA=20) and No CMDs mild BB (Controls n=60). There were 28 females and 2 males (93,3% and 6,7%) in the Bil CAP subgroup; 28 females and 2 males (93,3% and 6,7%) in the Bil RP

subgroup, 32 females (100%) in the Bil DAP subgroup; 22 females (95,6%) and 1 male (4,4%) in the Bil ART subgroup; 20 females (100%) in the Bil OA subgroup; 46 females and 14 males (76,7 % and 23,3%) in the Control subgroup. Mean age was about 30 (SD=8,9, range=17-47); 33,4 (SD=12,5, range=11-60); 33,2 (SD=10,5, range=17-51); 43 (SD=10,5, range=17-51); 46,4 (SD=9,3, range=16-70) and 34,2 (SD=15,0, range=16-70) in the aforementioned subgroups, respectively. There was a statistically and significant difference when age was compared in these subgroups (Kruskal-Wallis and Dunn´ statistics $p < 0,0001$): Bil CAP versus Bil ART ($p < 0,01$); Bil CAP versus Bil OA ($p < 0,001$); Bil RP versus Bil OA ($p < 0,01$); Bil DAP versus Bil ART ($p < 0,05$); Bil DAP versus Bil OA ($p < 0,01$); Bil OA versus Controls ($p < 0,01$). See Table 1 for further details.

Most common transitional signs, symptoms or "changes" indicating transitions were as follows: Bil CAP: Simple click, bilateral click, unilateral reciprocal click, and more intense pain in one joint; Bil RP: severer pain in one joint, unilateral or bilateral reciprocal click, and occasional transient locking; Bil DAP: severer unilateral pain, less frequent joint noises and crepitus "like" joint noise; Bil ART: reciprocal click, occasional transient locking, shooting or sharp pain, occasional crepitus; Bil OA: reciprocal crepitus, a burning sensation in the joint, click and crepitus occurring simultaneously; Control subgroup: simple or reciprocal click in one or two joints. See Table 2 for additional details.

Means in signs, symptoms or "changes" indicating transition from one TMJ-ID stage to other were as follows: Bil CAP 0,86 (SD=0,9, range=0-3); Bil RP 0,8 (SD=0,8, range=0-2); Bil DAP 0,8 (SD=0,7, range=0-2); Bil ART 1,78 (SD=0,9, range=0-4); Bil OA 0,8 (SD=0,8, range=0-2) and Controls 0,36 (SD=0,8, range=0-1). There was a statistically and extremely significant difference when the subgroups were contrasted (Kruskal-Wallis statistics with Dunn´s, $p < 0,0001$): Bil CAP versus Bil ART ($p < 0,01$); Bil RP versus Bil ART ($p < 0,01$); Bil DAP versus Bil ART ($p < 0,01$); Bil ART versus Bil OA ($p < 0,01$); Bil ART versus Controls ($p < 0,001$). See Table 3 for additional details.

Information about joint noises is provided here only for comparative and illustrative reasons. The frequency of joint noises in Bil CAP subjects was about 12/30=40%. Unilateral or bilateral single click was present in 8/12=66,7% subjects and unilateral or bilateral reciprocal click in 4/12 or 33,3%. The frequency of joint noises in Bil RP subjects was about 21/30=70%. 12/21=57,1% subjects demonstrated unilateral or bilateral single click, 1/21 or 4,8% unilateral or bilateral reciprocal click and 8/21=38,1% bilateral reciprocal click. As for Bil DAP, 29/32=90,6% subjects demonstrated joint noises. One subject or 3,4% demonstrated unilateral or bilateral single click and 28/29=96,6%, bilateral reciprocal clicking. Regarding subjects in the Bil ART subgroup, 14/23=60,9% demonstrated joint noises on self-report, clinical examination and use of a stethoscope. Bilateral reciprocal clicking was present in 13/14=92,8% and single bilateral crepitus in 1/14=7,1% of the subgroup. Regarding Bil OA, joint noises were evident in 20/20=100% of the subgroup. Single bilateral crepitus was present in 14/20=70% of the cases and bilateral simple or bilateral reciprocal crepitus in 6/20=30% subjects. As for the control subgroup, 12/60=20% subjects demonstrated joint noises on clinical examination. Unilateral or bilateral single click was present in 5/12=41,7%, unilateral or bilateral reciprocal click was observed in 6/12=50% of the subgroup. One subject or 8,3% presented with unilateral or bilateral crepitus. Because this subject did not present with a complain of headache and pain in the masticatory system and was not seeking treatment for CMDs, he was not included in any subgroup with CMDs and TMJ-IDs. See Table 4 for additional details.

Because TMJ-IDs noises vary in frequency and type in the course of these disorders but in the passage from arthralgia to OA, arthralgia still presents a high frequency of reciprocal clicking, we tested the hypothesis that reciprocal clicking increases in frequency from bilateral capsulitis to bilateral retrodiscitis, then to disc-attachment pain and finally to bilateral arthralgia. Because Chi-squared for independence ($p < 0,0001$) and Chi-Squared for trends ($p < 0,0001$), it seems clear that regarding reciprocal clicking, the subgroups were independent and there was a strong trend for an increase in frequency of reciprocal clicking from an early to a late TMJ-ID stage. See Table 4 for further details.

V. Discussion

1. Most common signs and symptoms or changes observed in each stage of TMJs-IDs:

Most common signs symptoms or "changes" observed in Bil CAP were as follows: more intense and more frequent pain in one TMJ as compared to the opposite side, single or nonreciprocal unilateral or bilateral clicking, and reciprocal or single clicking louder and more frequent in one side as compared to the other. As for Bil RP it was found that pain more intense in one TMJ than the opposite joint, single unilateral or bilateral clicking, unilateral or bilateral reciprocal clicking, and joint noise more intense and/or frequent in one TMJ as compared to the other, were the most common signs and symptoms. A combination of joint overload from frequent and intense parafunctional behaviors, acute or chronic trauma, and/or unstable occlusion cause disk displacement and deformation, increased joint friction and deterioration of cartilage^[7]. Unilateral or bilateral simple clicking were observed frequently in capsulitis and retrodiskal pain in the current study. Thus,

these findings are in agreement with one investigation^[8] reporting that early stages of TMJs-IDs are characterized by simple reciprocal clicking, no limitation of jaw movements and no degenerative signs when tomograms or MRI are examined. The outcome in the current investigation is also in line with one study^[9] reporting that stage I TMJ-ID is characterized by simple disk displacement without changes in disk morphology. In retrodiscitis (an early stage of TMJ-IDs), inflammation caused by repetitive trauma may affect the retrodiskal tissues as edema in this anatomic area may cause anterior disk displacement, posterior displacement of the joint condyle and acute malocclusion with painful limitation of mandibular movement^[10].

As for Bil DAP, most frequent signs and symptoms indicating transition were pain more intense in one TMJ as compared to the other, absence of joint noises, joint noises decreasing in frequency and intensity, crepitus "like" clicking and/or a combination of clicking and crepitus in the same TMJ. Further, in Bil DAP, jaw opening becomes progressively restricted. Murphy and colleagues^[11] evaluated etiology, clinical management and tissue engineering strategies for TMJ-IDs and indicated that in some TMJ-IDs patients, there is a transition stage characterized by a reduction of the joint disk, more intense pain, pain described as shooting or sharp and periodic locking. It is apparent that such researchers described the characteristics of DAP. DAP corresponds to stage II in Nitzan and Dolwick^[12] classification. Such stage is characterized by disk displacement with reduction, more intense pain and intermittent locking^[13]. This disorder may represent a transition stage to a more advanced TMJ-ID and is also characterized by more intense pain, pain described as shooting or sharp and occasional locking episode^[11]. The description of TMJ-IDs is not complete and some sub-stages do exist as some individuals may go through transitional stages for instance DAP and arthralgia before they reach an osteoarthritic stage^[14].

Regarding Bil ART, characteristic signs, symptoms or "changes" indicating transition were pain described as sharp, shooting or electric like, occasional periods of locking, a combination of joint clicking and crepitus during opening or closing, no joint noises, and pain more intense in one joint as compared to the opposite side. This description is in line with one investigation^[14] in CMD-IDs and arthralgia subjects in which TMJ-arthralgia was described as follows: "in terms of age, patients are usually older, pain is described as burning in 100% of the cases but some individuals describe pain as aching and sometimes sharp or shooting". Further, crepitus is present in a low percentage of arthralgia subjects". It is likely that arthralgia constitute the early or a sub-stage of TMJ-OA. This assumption is in line with one investigation^[15] evaluating diagnostic subgroups by demographics and symptom history, reporting that at least three osteoarthrosis/osteoarthritic populations can be differentiated by sex and age in epidemiological studies. In Bell's investigations^[16], TMJ arthralgia corresponds to "arthritic pain", which such investigator described as "a TMJ disorder characterized by inflammation of the articular surfaces associated with degeneration of the avascular fibrous tissue which constitutes the articular surface". Patients with this disorder describe such pain as dull, aching and persistently burning". A burning description has enormous diagnostic value and indicates damage to small unmyelinated C fibers which are vulnerable to compression^[17] and transmits nociceptive information. Such compression may be facilitated by subtle, partial or visible displacement and deformation of the joint disk and articular surfaces, respectively.

Regarding Bil OA, most common signs, symptoms or changes indicating transition included, reciprocal crepitus, a combination of joint clicking and crepitus during opening or closing, residual periods of locking, crepitus occurring twice during opening or closing, and pain described as burning which based on a previous investigation^[14], is a distinctive characteristic symptom of arthralgia of the TMJ. Regarding the Control subgroup, signs indicating transition and observed clinically were unilateral or bilateral single click and unilateral or bilateral reciprocal clicking. In the current investigation OA was observed in older patients (40-60 years old) and all subjects in this subgroup demonstrated the presence of bilateral crepitus indicating the presence of a degenerative inflammatory disorder. This observation is consonant with one investigation^[18] indicating that OA is generally recognized as a degenerative joint disease in which disk-displacement without reduction is present and is often regarded as an age-related disease. Severe pain was not a frequent complain in bilateral OA subjects. This is so as signs and symptoms of disk displacement without reduction tend to be alleviated during the natural course of the disorder^[13].

Many Bil -OA subjects in the current study complained of simple clicking, reciprocal clicking, bilateral crepitus and periods of locking. Such findings are in agreement with the investigation carried out by Ferrazzo and colleagues^[19] reporting that TMJ- OA patients usually present with chronic inflammation, joint tenderness, crepitus and limited mandibular movements. Signs and symptoms of OA indicating a transition stage described in the current study are in line with the description of OA subjects in one investigation^[20]. Researchers reported that pain, tenderness to palpation of the joint, clicking, popping and crepitus may be observed frequently in OA patients. Further, it has been reported^[20] that abnormal mechanical loads associated with parafunctional habits may induce OA like lesions. It seems apparent that early stages of TMJ-ID are characterized by the presence of unilateral or bilateral click and mild and moderate pain, intermediate stages, (for instance, DAP) by more intense pain and predominance of reciprocal click, and more advanced stages,

for instance arthralgia and TMJ-OA by the presence of reciprocal click, sharp or shooting pain, less intense pain and degenerative-inflammatory alterations represented by the high frequency of crepitus. In the current investigation all subjects in the OA subgroup were females. This outcome is in agreement with the studies of Kalladka^[21] asserting that that "OA may be unilateral or bilateral and has a strong preference for females that usually are characterized by an increased susceptibility to pain".

2.Frequency of transitions from one stage to the other based on the presence of signs and symptoms:

The frequencies of signs, symptoms or "changes" indicating transitions in the current study were as follows: Bil CAP: more intense pain in one TMJ (13/18=72,2%); unilateral or bilateral single clicking (8/18=44,4%); reciprocal unilateral or bilateral clicking (5/18=27,8%); Bil RP: More intense pain in one TMJ as compared with the opposite side (7/17=41,2%); single unilateral or bilateral click (6/17=35,3%); unilateral or bilateral reciprocal clicking (12/17=70,6%); occasional periods of locking (2/17=11,8%); **Bil DAP**: More intense pain in one joint (9/19=47,4%); no bilateral reciprocal clicking (11/32=34,4%), unilateral reciprocal clicking (2/32=6,3%); single bilateral click (1/32=3,1%); single unilateral click (1/32=3,1%); no joint noises (3/32=9,4%); joint noises decreasing in intensity or frequency (1/32=3,1%); joint noises increasing in frequency and intensity (2/32=6,3%); Bil ART= pain more intense in one joint (3/23=13%); bilateral reciprocal clicking (10/23=43,5%); electric shock pain (2/23=8,7%), no joint noises (7/23=30,4%), pain described as shooting or sharp (12/23=52,2%), periods of locking (7/23=30,4%), joint noises decreasing in frequency and intensity (2/23=8,7%), joint noises increasing in frequency and intensity (1/23=4,3%), crepitus "like" clicking (1/23=4,3%).

As for Bil OA, signs, symptoms or changes indicating a possible transition from an early or to a late stage of TMJ-ID were observed in 11/20 OA subjects=55%. Some of these 11 subjects demonstrated more than one sign or symptom indicating transition. Reciprocal crepitus was observed in 4/11 OA subjects=36,4%; clicking combined with crepitus was observed in 3/11=27,3%; a burning pain sensation was reported by 3/11=27,3% OA subjects; double crepitus (two crepitus on opening or closing) was observed in 2/11=18,2% OA subjects; periods of locking were reported by 2/11=18,2% subjects; bilateral reciprocal clicking was observed in 1/11=9,1% subjects.

Because clicking, burning, periods of locking and "reciprocal" crepitus were observed in many bilateral OA patients, it seems apparent that bilateral OA is an inflammatory-degenerative TMJ-ID which still retains many signs and symptoms of previous stages of TMJ-IDs. These observations are congruent with one investigation^[18] indicating that OA is frequently seen in joints with longstanding disk displacement without reduction. Thus, it seems apparent that disk displacement is the natural precursor of the signs and symptoms indicating OA. On the other hand, not all joint disks progress to a late stage of TMJ-IDs characterized by gross deformation and degeneration and /or by an extreme anatomic positioning. This observation is supported by the clinical evaluations demonstrating the presence of simple and reciprocal clicks in many Bil OA subjects. This is so as progressive changes do not occur in all joints and successful resolution occurs in the joint disk of many individuals^[13]. Further, most patients have improvement in signs and symptoms with time^[5] whereas in other patients, once joint breakdown initiates, OA can be deleterious leading to morphological deformity and functional obstruction^[11]. The aforementioned clinical signs and symptoms indicating transition that were observed in the population of patients with Bil OA in the current study are congruent with the description of OA signs and symptoms in one investigation^[22]: pain at rest, clicking, popping, crepitus, and limitation of jaw opening. However, to the extent of our knowledge, clicking and popping are not characteristics of OA and no doubt indicates that the joint where clicking and popping occur is in a transitional stage.

One investigation^[2] defines OA of the TMJ as a progressive disorder characterized by the presence of constant joint pain, painful chewing, displaced and deformed articular disks, joint noises and changes in condylar morphology. Because in the current study clinical evaluation and self-report revealed the presence of pain, tender joints, decreased range of motion, joint noises including simple click, reciprocal click and crepitus and some subjects presented with periods of locking, these findings are in line with those of Gupta and associates^[10] reporting the presence of limited jaw function, joint noises and crepitus in OA patients. Decreased range of motion, reciprocal click and periods of locking observed in Bil OA subjects more frequently constitute characteristics of DAP. From a practical standpoint this means that some Bil OA subjects did not progress completely to osteoarthritis of the TMJ. In the current investigation we considered more severe pain in one joint as a factor indicating transition as more severe pain may signal a higher level of inflammation, subtle or severe disk displacement or both. Congruent with this assumption, one investigation^[23] evaluated diagnosis and treatment of TMDs and suggested that inflammation indicates transition from adaptive to pathologic changes within the joint.

3.Frequency of joint noises

It is important to consider joint noises in the context of the type of TMJ-ID. In the current study we found a frequency of $12/30=40\%$ of joint noises in those subjects with a diagnosed of **Bil CAP**. Of those joint noises, $8/12=66,7\%$ were unilateral or bilateral single clicking and $4/12=33,3\%$ were reciprocal unilateral or bilateral clicking. $18/30=60\%$ CMDs and BB subjects with Bil CAP did not demonstrate joint noises on digital palpation and use of a stethoscope. Notwithstanding this, findings in the current investigation indicate that simple clicking predominates in subjects with Bil CAP. This is so as disk displacement is not present very frequently in subjects with capsulitis and if disk displacement with reduction is present, it is frequently associated with simple clicking. Clicking is a reliable sign of internal derangements indicating early stages of TMJ-ID^[2]. If joint noises are present in some TMJ-IDs, for instance Bil CAP and Bil RP, because there is no history of intermittent locking, the disorder may be classified as stage I^[5] which means that the joint disc reduces during jaw movement. Considering that joint noises are used by many clinicians as a reliable sign of CMDs, the frequency was relatively low in Bil CAP subjects. Consequently, this outcome is in line with one investigation^[22] indicating that in early stages of TMJ-ID joint noise or dysfunction is not so evident but may progress to difficulties in opening including a catching sensation. In the early stage of TMJ-ID, the joint disk retains its normal shape but over time, may become displaced^[24] increasing the likelihood of inflammation and joint noise.

Some patients complain of pain even when the disc is normal in position and shape. Intra-articular disorders may or may not affect the joint disc. They are usually caused by injury and damage to internal structures within the joint. In some cases, both macro and micro-trauma cause inflammation and damage to the joint disc^[5].

Regarding Bil RP, the frequency of joint noises was about $21/30=70\%$. Joint noises were absent in $9/30=30\%$ of RP subjects. $12/21$ or $57,1\%$ joint noises were unilateral or bilateral single clicks; $1/21$ or $4,8\%$ was unilateral or bilateral reciprocal click and $8/21=38,1\%$ were bilateral reciprocal clicks. If damage on the internal structures of the TMJ becomes chronic and is not compensated by defensive histological mechanisms, a severer inflammation and disk displacement become evident. The specific structures where pain and inflammation occur frequently in those subjects with TMJ-ID often include the retrodiskal tissues^[25]. This is so, as the posterior gradual displacement of the mandibular condyle compresses the highly innervated and vascularized structures posterior to the posterior band of the joint disk. Noteworthy to mention is that the frequency of reciprocal clicking increased from the Bil CAP subgroup ($33,3\%$) to the subgroup with bilateral retrodiskal pain ($42,9\%$). This probably means that severer and frequent damage and inflammation around the joint occur in those subjects with Bil RP. This does not mean that capsulitis progresses to retrodiskal pain in all subjects. This is so as signs and symptoms of some internal derangements of the TMJ may be alleviated during the natural course of the disease^[13]. Stress and tension associated parafunctions are major etiological factors in TMJ-IDs as they produce intense overload on structures with rich innervation and blood supply. Overload on the TMJ may induce increased friction and unstable occlusion^[7] which in turn may lead to lubrication disorders in more advanced stages of the disease.

Because in the current investigation the frequency of unilateral and bilateral reciprocal clicking in **Bil CAP** subjects was about $33,3\%$ as compared to the frequency of $42,9\%$ unilateral or bilateral reciprocal clicking in Bil RP, this probably represents a higher frequency of deformation, displacement and inflammation in some areas of the joint disk in Bil RP subjects. One investigation^[25] indicates that the specific structures that are in pain in cases of TMJ-IDs often include the retrodiskal tissue in which pain is the result of compression by distal displacement of the condyle against anatomic structures with rich innervation and abundant blood supply..

As for Bil DAP, 29 or $90,6\%$ subjects demonstrated joint noises and $3/32=9,4\%$ did not. Reciprocal bilateral clicking was present in $28/29$ subjects or $96,6\%$ and bilateral single joint click was observed in $1/29=3,4\%$ subjects. Although DAP is intrinsically associated with joint noises, in 3 subjects such noises were not observed. Findings in the current study demonstrated that a very high frequency of joint noises, including reciprocal clicking observed in most subjects, episodes of intermittent locking and more severe pain, are characteristics of Bil DAP. This also means that joint noises increase in frequency from Bil CAP, to Bil RP and then to Bil DAP. On the other hand, reciprocal clicking was rare in Bil CAP, increased in frequency in subjects with Bil RP and was the hallmark of subjects with DAP. TMJ-IDs including DAP are usually caused by micro or macro-trauma and result in ongoing signs and symptoms of pain, abnormal mobility of the jaw and disk displacement^[5]. Observations in the current study are in line with one investigation describing an "early intermediate stage" of TMJ-ID characterized by more frequent episodes of joint pain, loud clicking, forward disk displacement and episodes of transient locking^[8]. DAP corresponds to stage II TMJ-ID characterized by reducible disk displacement, mild or moderate deformity of the joint disc and occasional pathological alterations indicating early OA.^[26]

As for Bil ART, 14/23=60,9% subjects demonstrated joint noises and 9/23=39,1% did not. 13/14=92,8% of all subjects demonstrated bilateral reciprocal clicking and 1/14=7,2% demonstrated crepitus "like" noises. Noteworthy to mention is that the frequency of joint noises in Bil CAP was about 40%, increased to 70% and 90,6% in Bil RP and DAP, respectively, but decreased to 60,9% in Bil ART. The most plausible explanation for this lower frequency in Bil ART is the presence of a higher frequency of disk displacement without reduction in those with no joint noises (39,1%) on clinical examination. Thus, in many subjects with Bil ART and no joint noises, the joint disk is no longer a mechanical barrier, and thus the frequency of joint noises is lower as compared for instance with Bil-DAP and Bil RP. It may be that in many subjects with Bil ART (39,1%), their TMJ-ID progressed from Bil-DAP to disk displacement without reduction and later on to Bil ART. Thus, when TMJ-IDs subjects reach the Bil-ART stage, joint noises are observed less frequently during clinical examination in those subjects whose joint disks progressed from disk displacement without reduction to Bil ART as their disks still retain the status of "no reduction". In line with these observations, one study^[27] asserts that disc displacement without reduction frequently develops from an exacerbation of an earlier episode of reducible disc displacement (DAP). On the contrary, in those 60,9% subjects with Bil ART presenting with joint noises, we observed a variety of joint noises including bilateral or unilateral reciprocal clicking, crepitus "like" noises, and even simple clicks, demonstrating different "fates" of the joint disk that probably adopted different forms and positions from Bil CAP or from bilateral DAP to Bil ART.

Regarding those subjects with no joint noises (39,1%) in Bil ART, it may be that the joint disk has undergone significant disk displacement and deformation that no longer constitute a mechanical barrier when the joint condyle displaces anteriorly and inferiorly. Supporting in part this point of view, one longitudinal investigation^[26] evaluated 217 joints in 165 subjects. Researchers reported that with time the joint disc may become displaced progressively forward and undergo greater disc deformity in the natural course of non-reducing disc displacement. Disc length and position become progressively worse in patients with disc displacement without reduction. Patients presenting signs and symptoms of disc displacement without reduction experience greater deterioration of disc status, shorter length and severe distortion^[26]. The frequency of 60.9% of joint noises in subjects with Bil ART is quite similar to the frequency of 72% reported in a previous investigation in patients with TMJ arthralgia^[14].

In the current investigation 20/20=100% OA subject demonstrated joint noises: Of all these noises 14/20=70% were bilateral crepitus, 6/20=30% were reciprocal unilateral or bilateral crepitus, that is, noises occurring on opening and closing as if they were remnants or modifications of previous reciprocal clickings of previous TMJ-IDs stages.. On clinical evaluation most OA subjects demonstrated the presence of bilateral crepitus, but single clicking, popping or locking or "residual noises" from previous TMJ-IDs were reported and observed in some subjects. Thus, this outcome is in line with one study^[28] reporting that clicking, popping and locking can also be observed in OA patients. One investigation^[29] indicates that TMJ-OA is also associated with clicking sounds and intermittent locking and grating sounds are evident in a late stage of the disease.

Noteworthy to mention is that all those subjects with bilateral OA demonstrated crepitus. However three types of crepitus were observed more frequently: bilateral crepitus, unilateral or bilateral reciprocal crepitus and double crepitus. Consequently, this observation in the sample of Bil OA subjects, is congruent with one investigation^[18] reporting that disk displacement is the most common abnormality in patients with pain and TMJ dysfunction. Because Bil OA was observed in subjects with a mean age of about 46,4 years old, the outcome in the current investigation is in accordance with one study^[10] indicating that OA symptoms begin in the fifth to six decade of life. TMJ-OA can occur at any age, however, it is observed with greater frequency as age increases and by 65 years of age the proportion of OA increases dramatically and radiographic signs are evident^[21]. As subjects in the current investigation demonstrated the presence of different types of crepitus, consequently, this outcome is not in line with one study^[20] reporting that clicking and popping sounds may be observed in subjects with TMJ-OA.

To summarize, it seems clear that worsening or transformation of bilateral TMJ-ID into more advanced stages is characterized by the presence of single or reciprocal clicking in the first two stages (capsulitis/synovitis and retrodiskal pain), the predominance of reciprocal clicking in intermediate stages (disk-attachment pain, TMJ-arthralgia) and finally, the substitution of single and reciprocal click by bilateral crepitus. These observations are in line with one study^[18] indicating that the most advanced imaging techniques to assess the TMJ together with clinical methods revealed that disk displacement is the most frequent abnormality in patients with painful and dysfunctional TMJs. The frequency of single unilateral or bilateral click in early stages of TMJ-ID, then the observation of a higher frequency of reciprocal clicking in disk attachment pain, the decrease in frequency of joint noises in bilateral arthralgia and the high frequency of bilateral crepitus in bilateral OA, clearly indicate that joint noises progress from simple, to reciprocal click in early stages and then to crepitus in more advanced stages of TMJ-ID. However, this progression does not occur

in all subjects with TMJ-IDs. These observations and data in the current investigation are congruent with one investigation^[2] asserting that "clicking is a reliable sign of TMJ-ID while grating or crepitus is a sign of advanced degenerative disease such as osteoarthritis and osteoarthrosis.

4. The highest score in signs, symptoms, or "changes" which would potentially indicate transition from an earlier or to a late stage of internal derangement was observed in Bil ART. Most frequent signs, symptoms or "changes" in this TMJ-ID stage were joint noises occurring less or more frequently, periods of intermittent locking, bilateral reciprocal clicking, absence of joint noises and pain described as shooting or sharp. Most of these sign and symptoms are observed more frequently in previous stages of TMJ-IDs, for instance DAP in which periods of intermittent locking are the hallmark. Because we observed higher frequency of signs, symptoms or changes indicating transition to or from other stage of TMJ-ID in Bil ART, this observation is consistent with the hypothesis that "some stages of TMJ-IDs are characterized by a higher frequency of signs, symptoms or changes indicating transition from an early or to a late stage of TMJ-ID". Even though there may be signs and symptoms indicating degenerative processes in arthralgia, this disorder should be considered an independent stage in which a variety of signs and symptoms predominates. This is so as arthralgia seems to be a combination of preceding stages of TMJ-IDs (disk-attachment pain and disk displacement without reduction) and the next stage (Osteoarthritis). Unfortunately, and in spite of the richness of data from clinical and MRI observations, arthralgia has not been evaluated or considered as an independent stage. In this regard, one investigation^[5] defends the notion that current systems of classification are not complete and updates are necessary to include a larger variety of internal derangements of the TMJ. It may be that arthralgia corresponds to stage IV TMJ-IDs described by Tanaka and colleagues^[29]. They described some signs and symptoms that are very similar to those observed in patients with arthralgia including the following: chronic joint pain, headache, restriction in jaw movements, a markedly thickened disk anteriorly displaced and some degenerative alterations. The clinician must bear in mind that not all TMD-IDs fit into current classifications of TMJ-IDs^[6]. Thus, arthralgia may correspond to an independent stage or at least should be considered as an "early OA stage". From our point of view, arthralgia is an early degenerative stage of TMJ-ID and many patients in the Bil ART subgroup complained of persistent pain, popping, clicking or even periods of intermittent locking reflecting remnants of earlier stages of ID. This assumption is congruent with one investigation^[30] asserting that in more advanced stages of TMJ-ID, there may be some degenerative signs, popping, clicking sounds and occasional locking.

VI. Conclusion

Even though in the current research we report valuable data in different stages of TMJ-IDs in subjects that were classified according to accepted criteria for TMJ-IDs, this study has some weaknesses that should be acknowledged: First, the cross-sectional nature of the study does not allow us to make definitive or more solid conclusions. This is very true when we discuss progression of some TMJ-ID from one stage to the other. Second, the subgroups with bilateral arthralgia and bilateral OA were relatively small, which may have seriously compromised the strength of statistical tests used in the current study. Third and last, we did not include some subgroups presenting with disk displacement without reduction and those with "stuck disks" as their diagnosis are dependent on excellent clinical observations and magnetic resonance imaging. With these observations in mind, the investigation is valid regarding the description of some signs and symptoms indicating potential transition from one stage to the other. Further, sound criteria were used to include subjects in subgroups presenting with TMJ-IDs. We hope that this investigation encourage additional studies in the field of internal derangements of the TMJ. Finally, we report abundant data about joint noises observed in different stages of TMJ-IDs. Further studies in this interesting field of Medicine and Dentistry are welcome and would be extremely useful to elucidate different aspects in the field of transition and progression of TMJ-IDs.

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Bilateral Osteoarthritis	Reciprocal crepitus, burning pain (occasional), simultaneous click and crepitus, less severe pain
Controls	Simple or reciprocal click, click occurring more frequently

Table 3: Frequency of signs, symptoms or "changes" indicating transition in some TMJ-IDs subgroups.

Subgroup	Mean	SD	Range
Bil CAP	0,86**	0,9	0--3
Bil RP	0,8	0,8	1--2
Bil DAP	0,8	0,7	0--2
Bil ART	1,78	0,9	0-4
Bil OA	0,8	0,8	0--2
Controls	0,36	0,8	0--1

**Kruskal-Wallis with Dunn' statistics (p<0,0001): Bil CAP versus Bil ART (p<0,01); Bil RP versus Bil ART (<0,01); Bil DAP versus Bil ART (p<0,01); Bil ART versus Bil OA (p<0,01); Bil ART versus Control (p<0,001).

Table 4: Joint noises in TMDs subjects with different types of TMDs-IDs. ID type=Internal derangement type; Uni/Bil=Unilateral or bilateral; Bil Rec=Bilateral reciprocal; Uni/Bil Rec crep=Unilateral or bilateral reciprocal crepitus.

ID TYPE	TOTAL NOISE FREQUENCY		UNI/BIL SINGLE CLICK		UNI/BIL REC CLICK		BIL REC CLICK		SINGLE BILATERAL CREPITUS		UNI/BIL REC CREP	
	n	%	n	%	n	%	n	%	n	%	n	%
	BIL CAP=30*	12	40	8	66,7	4	33,3	0	0	0	0	0
BIL RP=30*	21	70	12	57,1	1	4,8	8	38,1	0	0	0	0
BIL DAP=32*	29	90,6	1	3,4	0	0	28	96,6	0	0	0	0
BIL ART=23*	14	60,9	0	0	0	0	13	92,8	1	7,1	0	0
BIL OA=20	20	100	0	0	0	0	0	0	14	70	6	30
CONTROL=60	12	20	5	41,7	6	50	0	0	0	0	1	8,3

* Chi-squared for independence (p<0,0001), Chi-squared for trends (p<0,001): The frequency of reciprocal clicking increased from an early to a late stage of TMJ-ID.

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