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Discomallear Ligament: A Review with a clinical Approach

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Abstract *— The discomallear ligament is described as a fibrous connection that anatomically and functionally relates the malleus bone in the middle ear to the posteromedial portion of the joint capsule through the petrotympanic fissure. It is a structure that presents important clinical aspects, since it may be related to otologic symptoms in temporomandibular joint dysfunctions. The objective of the present study was to perform a systematic review of the presence of the discomallear ligament, its possible influences on otologic symptoms and correlation with temporomandibular dysfunction. The analyzed sources of the literature review were searched in PubMed, Scielo, Web of Science, Lilacs, Google Scholar and Ebsco databases through a combination of keywords. An analysis of anatomical specimens was performed through the inspection of 277 adult skulls and 9 infant skulls, in order to verify the presence of foramina in the petrotympanic fissure on both sides. A computed tomography image was included in this study and showed a hypodense circular structure suggestive of foramen and possible passage of this ligament towards the disc of the temporomandibular joint. The evaluation of the anatomical parts showed that the adult skulls analyzed, about 90% had a foramen on both sides, 1.44% on the right side only, 4.33% on the left side only and 3.61% did not present foramen in any of the sides. About the children's skulls, 33.3% had a foramen on both sides, 33.3% on the right side and 33.3% had no foramen on either side. In results, the methods evaluated and the studies analyzed show the anatomical relationship between the tympanic cavity and temporomandibular joint, as well as the existence of the discomallear ligament and its possible influence on the otologic symptoms caused by temporomandibular disorders.*

Keywords *— **Temporomandibular joint, Malleus, Middle ear, Temporomandibular joint disorders.***

I. INTRODUCTION

The stomatognathic system is closely related anatomically and ontologically to the region surrounding the middle ear structures (RAMÍREZ ARISTEGUIETA, BALLESTEROS ACUÑA, & SANDOVAL ORTIZ, 2009)(RODRÍGUEZ VÁZQUEZ, J, MERÍDA VELASCO, J, & JIMÉNEZ COLLADO, 1993). The discomallear ligament is one of the fibrous connections that relates the malleus to the posteromedial portion of the temporomandibular joint capsule (PINTO, 1962), is also described as a triangular-shaped band of connective tissue whose base is continuous with the posterior region of the joint capsule and disc, which is directed to the middle ear through the petrotympanic fissure (COLEMAN, 1970).

Little mentioned in the anatomy books (MORGAN, 1982)(BOCHENEK & REICHER, 1997)(STANDRING, 2005)(ALVES & DEANA, 2010), the discomallear ligament was first referred to in 1954 (REES, 1954), but its detailed description was performed in 1962 and is also described and demonstrated by several other authors (PINTO, 1962). It is a structure that penetrates the caudal end of Meckel's cartilage corresponding to an embryological remnant of the lateral pterygoid muscle (CHEYNET, GUYOT, RICHARD,

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LAYOUN, & GOLA, 2003). However, other researchers stated that Meckel's cartilage has no influence on the development of the temporomandibular joint and also that during the embryonic stage there is no evidence that the lateral pterygoid muscle attaches to the malleus (FURSTMAN, 1963)(YUODELIS, 1966).

The discomallear ligament is a structure that presents important clinical aspects (ALVES & DEANA, 2010). Some authors state that dysfunctions in the temporomandibular joint (TMD) cause alteration of the discomallear ligament, causing a displacement of the malleus, resulting in some symptoms such as tinnitus and deafness (PINTO, 1962)(IOANNIDES & HOOGLAND, 1983). Although the risks of otological symptoms are greater in individuals presenting with disorders such as pain during the opening and closing of the mouth or palpation of the temporomandibular joint (PASCOAL, 2001)(LAM, LAWRENCE, & TENENBAUM, 2001). The origin and possible relations between these structures are not fully understood (FELICIO, FARIA, & DA SILVA, 2004). This structure can usually be observed in dissected anatomical pieces. However, it is also possible to visualize it in concomitant computed tomography in sagittal sections. In the images, furthermore to discomallear ligament, structures related to temporomandibular joint are also observed within the petrotympanic fissure. In Cone Beam CT images, the petrotympanic fissure resembles a small lumen that extends in the direction of the epitympanic recess in the upper portion of the tympanic cavity, where inferiorly the malleus bone is located. Studies demonstrate the visualization in tomographic images and anatomical pieces that discomallear ligament connects to the head and anterior region of the malleus bone, disposed from the posterior and superior portion of the mandibular fossa, located in the temporal bone (ARAI & SATO, 2012).

Thus, the aim of the present study was to perform a systematic review of the presence of the discomallear ligament, its possible influences on otologic symptoms and correlation with temporomandibular dysfunction.

II. MATERIALS AND METHODS

2.1 Computed tomography (CT)

A computed tomography image was used to evaluate the presence of the discomallear ligament. The image covers the region of a temporomandibular joint on the left side and was obtained by a scanner I-CAT CT (Cone Beam Volumetric Tomography [I-CATVisionProgram]).

2.2 Anatomical Pieces Evaluation

This stage was based on a careful evaluation of skulls belonging to the Department of Biological Sciences, Anatomy Discipline of School of Dentistry of Bauru- University of São Paulo (FOB-USP). The inspection of the pieces was done with the naked eye and with the aid of a hand magnifier with lighting 75 mm in diameter and increase of 6 times, of the brand Western 3455. It consisted in identifying the presence or absence of foramina in the region of the petrotympanic fissure on the left and right sides of 277 (two hundred and seventy-seven) adult skulls and 9 (nine) children skulls.

2.3 Data source

This literature review contains information available in the databases PubMed, Scielo, Web of Science, Lilacs, Google Scholar and Ebsco, using the following keywords: discomallear ligament / discomalleolar ligament, temporomandibular disorders, temporomandibular dysfunction, and petrotympanic fissure. This led to the initiation of a search strategy and articles published between 2006 and 2016 were included, using a keyword search to obtain information about the discomallear ligament (figures 1-6).

2.4 Data extraction

After analyzing and reviewing the researched scientific articles, ten relevant studies related to the objectives of the study were found. Several studies resulting from the research were read with the objective of identifying relevant information on the subject in question.

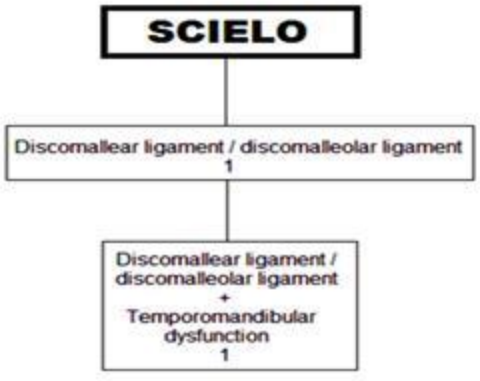

Fig.1: Scielo Keywords combination.

Papers extracted from the Scielo database:

1- Frequency of occurence of the discomalleolar ligament in the adult man (ALVES; DEANA, 2010).

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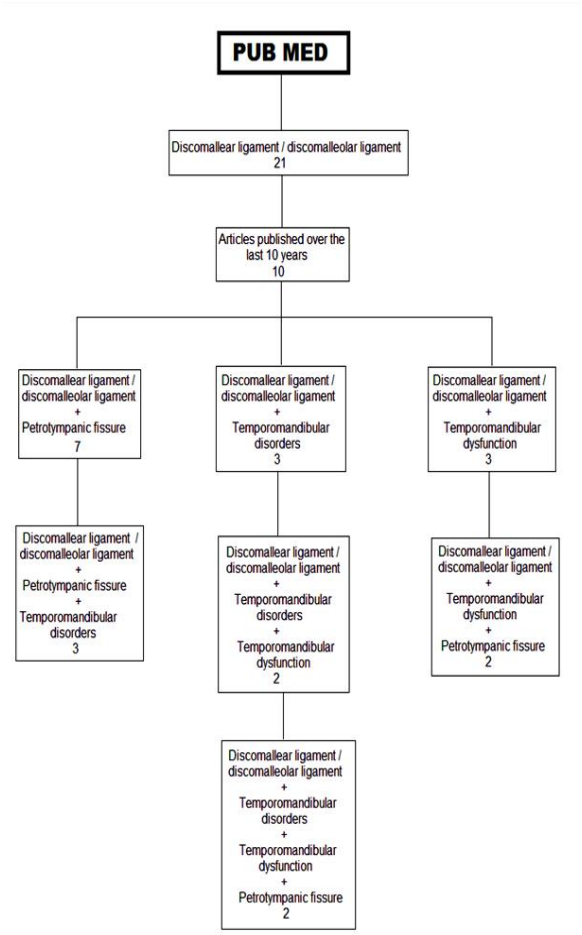

Fig.2: PubMed Keywords combination.

Papers extracted from the PubMed database:

1- Prevalence of the types of the petrotympanic fissure in the temporomandibular joint dysfunction (ÇAKUR et al., 2011).

2- Classifications of tunnel-like structure of human petrotympanic fissure by cone beam CT (SATO et al., 2008).

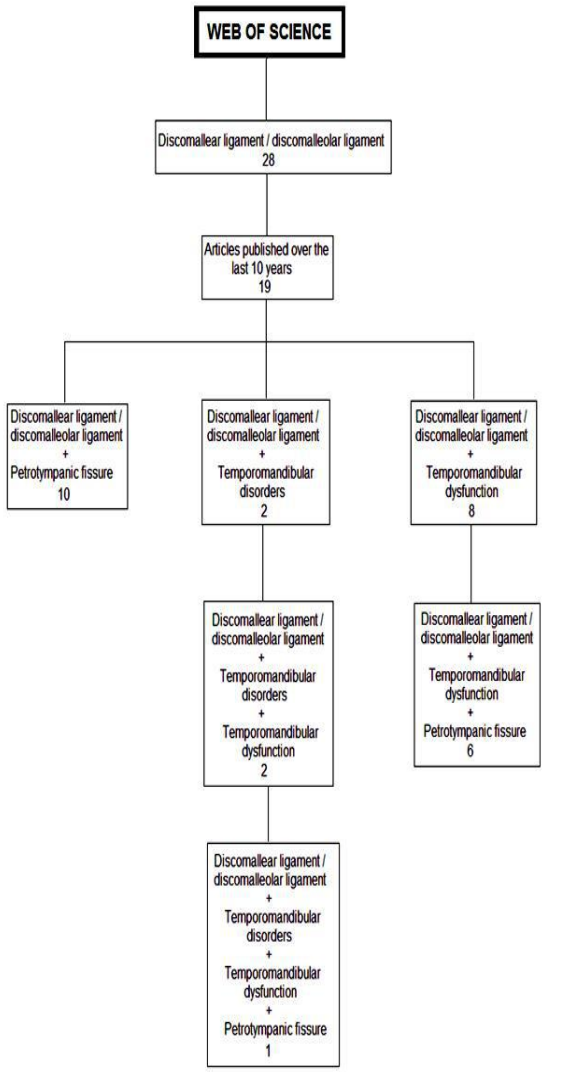

Fig.3: Web of Science Keywords combination.

Papers extracted from the Web of Science database:

1- Correlation between tinnitus and petrotympanic fissure status among patients with temporomandibular joint dysfunction (ÇAKUR; YASA, 2016).

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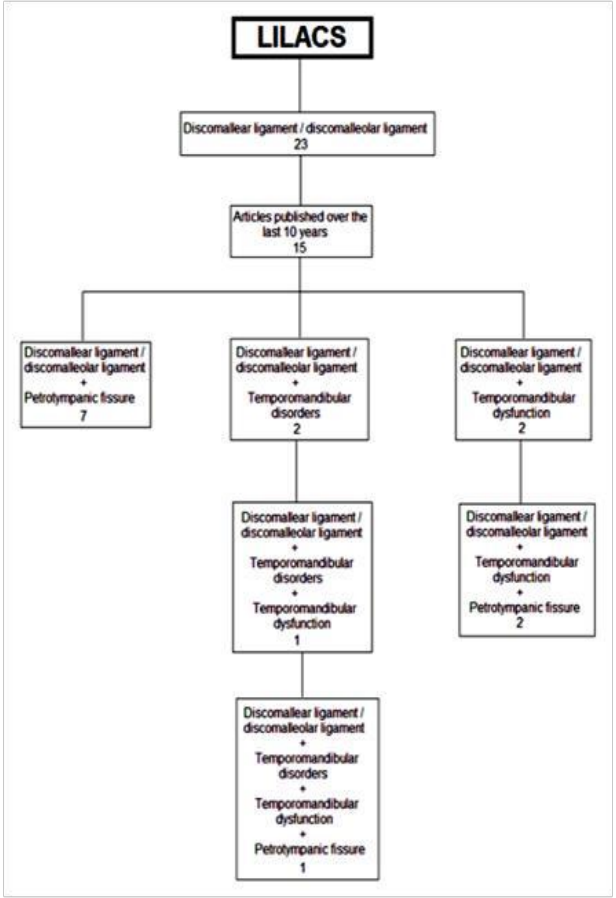

Fig.4: LILACS Keywords combination.

Papers extracted from the LILACS database:

1- Classifications of tunnel-like structure of human petrotympanic fissure by cone beam CT (SATO et al., 2008).

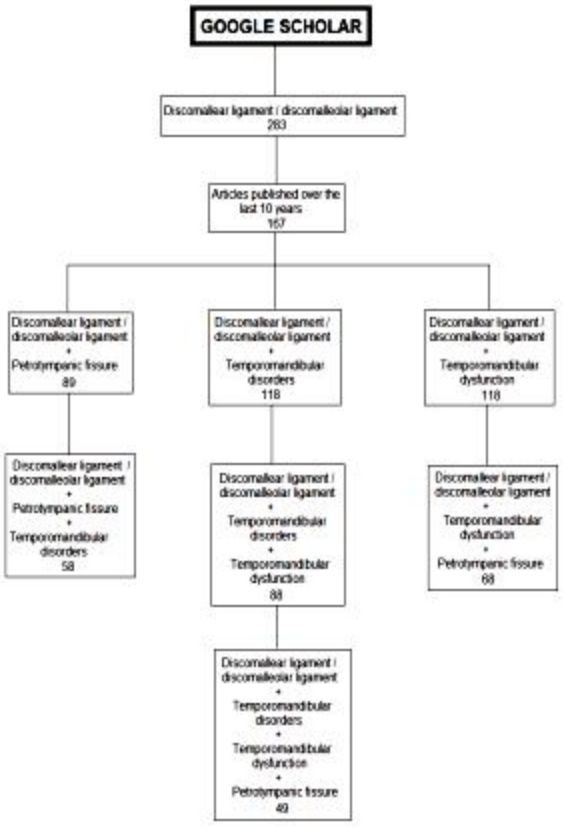

Fig.5: Google Scholar Keywords combination.

Papers extracted from the Google Scholar database:

1- A direct anatomical study of the morphology and functionality of disco-malleolar and anterior malleolar ligaments (ARISTEGUIETA; ACUNA; ORTIZ, 2009).

2- Anatomical study of the human discomallear ligament using cone beam computed tomography imaging and morphological observations (ARAI; SATO, 2011).

3- A study of the discomalleolar ligament in the adult human (ROWICKI; ZAKRZEWSKA, 2006).

https://dx.doi.org/10.22161/ijaers.6.6.6 *ISSN: 2349-6495(P) | 2456-1908(O)*

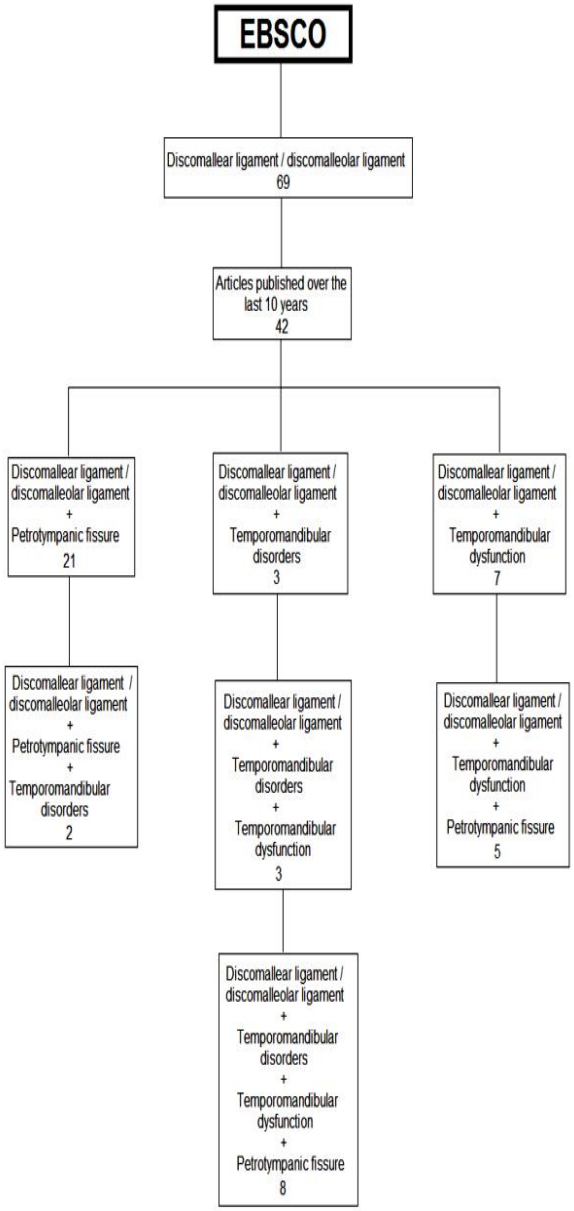

Fig.6: EBSCO Keywords combination.

Papers extracted from the EBSCO database:

1- Anatomical and functional aspects of ligaments between the malleus and the temporomandibular joint (SENCIMEN et al., 2008).

2- Signs and Symptoms of Temporomandibular Joint Disorders Related to the Degree of Mouth Opening and Hearing Loss (KITSOULIS et al., 2016).

3 - Ossification of the petrotympanic fissure: morphological analysis and clinical implications (MONTEIRO; ENNES; ZORZATTO, 2011).

III. RESULTS

Computed tomography (CT) and Anatomical Pieces Evaluation

It can be observed that the tomographic image (figure 7) used in the present study has a circular hypodense structure, in the region of the petrotympanic fissure, near the mandibular fossa of the temporal bone, suggestive of foramen and a possible passage of the discomallear ligament towards posterior region of the joint capsule of the disc of the temporomandibular joint.

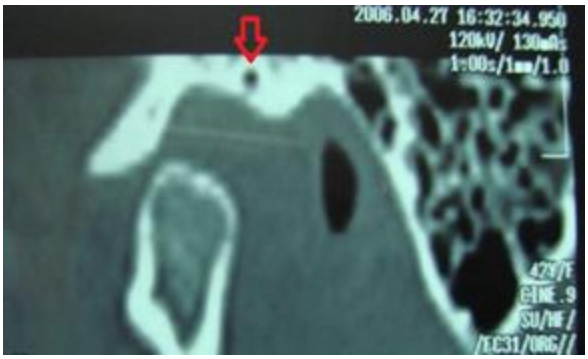

Fig.7: Possible place of passage of the discomaleolar ligament demonstrated by the red arrow.

The evaluation of the skulls resulted in two tables, one for adult skulls (table 1) and one for children's skulls (table 2). About adult skulls analyzed, 90% presented foramen on both sides, 1.44% presented foramen only on the right side, 4.33% presented foramen only on the left side, and 3.61% presented no foramen on either side. Of the children's skulls, 33.3% had a foramen on both sides, 33.3% on the right side, and 33.3% had no foramen on either side. Two images were obtained (Figures 8 and 9) in order to demonstrate to the naked eye, the presence of the foramina in the petrotympanic fissure.

Table 1: Analysis of absence or presence of foramen in the region of petrotympanic fissure in adult skulls.

	BOTH SIDES	**JUST ON THE RIGHT SIDE**	**JUST ON THE LEFT SIDE**
ABSENCE OF FORAME	10	X	X
PRESENCE OF FORAME	251	4	12

Table 2: Analysis of absence or presence of foramen in the region of petrotympanic fissure in children's skulls.

	BOTH SIDES	**JUST ON THE RIGHT SIDE**	**JUST ON THE LEFT SIDE**
ABSENCE OF FORAME	3	X	X
PRESENCE OF FORAME	3	3	0

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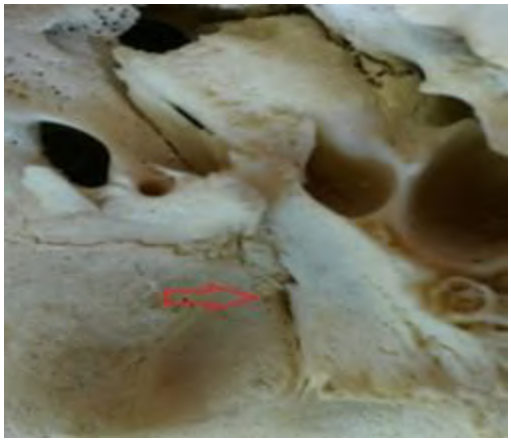

Fig.8: Presence of foramen in the petrotympanic fissure on the right side, demonstrated by the red arrow.

Fig.9: Presence of foramen in the petrotympanic fissure on the left side, demonstrated by the red arrow.

Literature review

After analyzing the combination of the keywords used for this literature review, a table with a brief summary of each of the extracted papers was obtained (table 3).

Table 3: Summary of Articles included in this Review.

Authors	Objective	Methods	Results	Conclusion
Çakur et al. (2011)	To investigate the prevalence of petrotympanic fissure types in temporomandibular dysfunction with dental tomography and correlation with age.	134 TMD patients examined for type of petrotympanic fissure by means of dental tomography. Three types were described: wide tunnel structure (type 1); tunnelled structure at the entrance of the petrotympanic fissure that gradually decreases towards the tympanic cavity (type 2), a tunnel-shaped structure that is well open at the entrance of the mandibular fossa, with a flat shape in the middle and a narrow exit in the tympanic cavity (type 3).	In the DVT (dental tomography) scans, PTF (petrotympanic fissure) types 1, 2 and 3 were observed in 67.2%, 1.5% and 31.3% of the cases, respectively. We found no significant relationship between age or gender and PTF type`.	The low percentage of type 2 PTF and high percentage of type 1 PTF should be taken into account during pre-surgery planning related to TMD.
Sato et al. (2008)	To define the morphological characteristics of the discomallear ligament by Cone-Beam Computed	The CBCT of PSR 9,000 N (Asahi Roentgen Industry, Kyoto, Japan) was used to acquire temporomandibular	The CBCT images revealed three types of structures in the middle region of the petrotympanic fissure toward the malleus	The structures are important to define the malleus limited movement and the morphological characteristic of the

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	Tomography (CBCT) and the anatomical dissection of Japanese cadavers.	joint images of 14 human cadavers that later had this region dissected. .	bone: wide tunnel (29.2%, 7/24, type 1), a widely open tunnel form at the entrance of the petrotympanic fissure (20.8%, 5/24, type 2), and the tunnel form is widely open at the entrance of the mandibular fossa, with a tunnel and flat form in the middle and narrow exit in the tympanic cavity (41.7% 10/24, type 3).	ligaments in this bone may be related to temporomandibular joint pain, dysfunction and auditory function.
Alves et al. (2010)	To determine the frequency of occurrence of the discomallear ligament in the adult man.	20 hemi-heads dissected with the purpose of exposing the articular disc, ossicles of the middle ear, lateral pterygoid muscle and other structures of the region.	In all cases, the malleus and disc of the temporomandibular joint were connected by ligaments that formed a fibrous structure in the form of a thin blade.	The discomallear ligament was found in all cases and may be considered an intrinsic ligament of the temporomandibular joint.
Çakur et al. (2016)	To evaluate the correlation between tinnitus and petrotympanic fissure subtypes in patients diagnosed with temporomandibular joint dysfunction (TMD).	100 patients with TMD (50 with tinnitus, 50 without tinnitus) underwent concomitant computed tomography (CBCT) had the images analyzed and petrotympanic fissure classified as type 1 (wide tubular formation), type 2 (double conical structure) or type 3 (single conical structure).	Although there was a negative correlation between tinnitus and petrotympanic fissure type ($P < 0.001$), there was no correlation between age and tinnitus or between age and petrotympanic fissure subtype. There was no significant association between gender and tinnitus or petrotympanic fissure ($P > 0.05$).	A short and broad petrotympanic fissure (type 1) may be associated with a higher incidence of tinnitus in patients with TMD.
Ramirez et al. (2009)	Study of morphometric and functional aspects of anterior discomallear and malleolar ligaments.	3 temporal bone pieces of 12 cadavers were microdissected to expose ligaments under study. Electronic caliber (Mitutoyo) for recording measurements in mm and applying forces to the mandible for reproduction of some physiological and	Mean lengths of the anterior discomallear and malleolar ligaments of 6.88 mm (SD 0.81) and 4.22 mm (SD 1.17), respectively. Malleus movement with discomallear traction in 30.5% of samples. Correlation between the movement of the malleus and the length of the discomallear (R2	There was an anatomic and functional relationship between the human temporomandibular joint and the middle ear.

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		pathological scenarios.	= -0.499, p <0.05). Both ligaments present in all specimens.	
Arai et al. (2011)	Study of the morphological, macroscopic, histological structure of the discomallear ligament (DML) and evaluation of neuronal structures within the distribution of substance P (SP) and peptide related to the calcitonin gene (CGRP).	Dissection and extraction of temporal bones containing the temporomandibular joint of 27 human cadavers. Parts submitted to concomitant computed tomography, measurements and immunohistochemical methods.	The posterior area of the DML articulates with the head and anterior process of the malleus through the petrotympanic fissure, forming a narrow channel. This was associated with bone mobility. In the anterior and posterior connective tissue of the DML associated with the disc, fibers of the nerves CGRP-, PGP9.5- and SP-positive were located around numerous blood vessels.	The structure of the petrotympanic fissure by which the discomallear ligament attaches to the malleus, as well as the histological and radiographic profiles of its structure, showed a relation with the mobility of the malleus.
Rowicki et al. (2006)	To determine the frequency of occurrence and morphology by means of endoscopic visualization of the discomallear ligament (DML) and its attachments, and if the applied tension could trigger the movement of the malleus.	Evaluate of 14 samples of the temporomandibular and tympanic cavity by means of an endoscope and then by coarse dissection of an operating microscope.	4 cases had a strip of tissue in the temporomandibular joint, known as Pinto's ligament. Presence of DML in 11 cases, triangular in 7 cases, and longitudinal in 4 cases. Malleus movement present in 3 cases.	There is a clear connection between the temporomandibular joint and the tympanic cavity.

https://dx.doi.org/10.22161/ijaers.6.6.6 *ISSN: 2349-6495(P) | 2456-1908(O)*

Kitsoulis et al. (2011)	Examination of the relation between signs and symptoms of temporomandibular dysfunction (TMD) and mouth opening, gender, joint and auditory symptoms and hearing loss.	464 university students. Mouth opening measured with Vernier calipers. Anamnestic questionnaire applied to stratify them into four groups based on the severity of TMD. Hearing symptoms and a recorded audiogram for each subject as well.	Overall incidence of signs and symptoms of TMD were 73.3%, higher in women (p-value 0.0001 <0.05). Hearing symptoms were associated with TMD severity (p-value 0.0001 <0.05) as well as maximum mouth opening (p-value 0.004 <0.05). Audiometry showed that moderate and severe TMD was associated with hearing loss of medium and low tones, respectively (p-value 0.0001 <0.05). TMJ pain (p value 0.0001 <0.05), TMJ ankylosis (p-value 0.0001 <0.05), bruxism (p-value 0.0001 <0.05) and ear itching (p-value 0.0001 <0.05) were also statistically different between TMD and non-TMD.	Signs and symptoms of TMD are more common and severe in women. The severity of TMD correlated with the degree of mouth opening and the number of auditory symptoms. The absence or presence of mild TMD was associated with normal audiograms, while moderate and severe TMD were related to hearing loss in low and low tones, respectively. Bruxism, joint ankylosis, joint pain and ear itching were more common in TMD than patients without TMD.
Sencimen et al. (2008)	To investigate the anatomical topography and the relation between the ligaments, malleus and temporomandibular joint and to determine the role of these ligaments in the movement of the malleus.	The malleus, incus, petrotympanic fissure (PTF), chorda tympani, anterior malleolar ligament (AML), discomallear ligament (DML), malleomandibular ligament, sphenomandibular ligament and disc joint were explored in 15 skulls. Tensile and tensile tests performed to clarify the role of these structures in the movement of the malleus.	In 12 cases two ligaments connected to the anterior part of the malleus. Of this same portion, another ligament that went to PTF was seen in 3 cases. In all of cases, the DML joined the retrodiscal tissues. In the other 3 cases, the medial and lateral parts of the ligament were attached to the retrodiscal tissue after passage through PTF.The thickness of the ligaments differed among the specimens. When the tension was applied to the DML, no malleolar movement	The overstretched of the condyle together with the ligaments between the inner ear ossicles and the TMJ may be the reason for unexplained otological problems.

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			occurred, but when the AML was overloaded, the movement was significant in 5 corpses; small movement in 6 corpses, and no movement in 4 corpses.	
Monteiro et al. (2011)	To characterize morphologically the calcification in the petrotympanic fissure through three observations: macroscopic observation to the naked eye, stereomicroscopic observation and measurements made from digital images.	Macroscopic and stereomicroscopic analysis of the petrotympanic fissure of 30 human skulls. Analysis of scanned images with the UTHSCSA ImageTool 3.0 computer program. Measurement of the total extension of the areas of cracks and ossification.	Macroscopic analysis: areas suggestive of calcification in 27 fissures (45%). Stereomicroscopic analysis: areas of calcification in 40 fissures. (66.6%). The location of the areas of calcification was not regular considering the total length of the various fissures and their division into median and lateral regions, occurring randomly along the total length of the fissures.	Macroscopic analysis was not an appropriate method for this evaluation and the ossification of fissures increased with aging, suggesting its influence on the causes of otalgia in cases of temporomandibular joint dysfunction.

IV. DISCUSSION

The aim of the present study was to perform a systematic review of the presence of the discomallear ligament, its possible influences on otological symptoms and correlation with temporomandibular dysfunction. Therefore, the methods evaluated and the studies analyzed shows the anatomical relationship between the tympanic cavity and temporomandibular joint, as well as the existence of the discomallear ligament and its possible influence on the otologic symptoms caused by temporomandibular disorders.

In addition, several studies state that there is an obvious anatomic and functional relationship between temporomandibular joint and the tympanic cavity (RODRÍGUEZ VÁZQUEZ, MÉRIDA VELASCO, MÉRIDA VELASCO, & JIMÉNEZ COLLADO, 1998)(CHEYNET et al., 2003)(ROWICK & ZAKRZEWSKA, 2006)(RAMÍREZ ARISTEGUIETA et al., 2009) (ÇAKUR, SÜMBÜLLÜ, DURNA, & AKGÜL, 2011). The discomallear ligament is one of the structures that allows this relationship and is not described in anatomical books (PATURET, 1951)(SAPPEY, 1867)(CRÉPY, 1967)(TESTUT & LATARJET, 1975)(ROMANES, 1987)(ROUVIÈRE & DELMAS, 1987)(DUBRUL, 1990)(WILLIAMS, 1995). This ligament consists of a layer of superior fibers that insert into the anterior malleus process and the bone wall of the squamous portion of the petrotympanic fissure, and a layer of inferior fibers surrounding the anterior malleolar ligament (AML), the remnant of Meckel's cartilage, the chorda tympani and insert into the tympanic wall of the temporal bone (OGÜTCEN-TOLLER, 1995). Besides, it is considered an intrinsic ligament of the temporomandibular joint (RODRÍGUEZ VÁZQUEZ, MÉRIDA VELASCO, & JIMÉNEZ COLLADO, 1992)(RODRÍGUEZ VÁZQUEZ, J et al., 1993)(RODRÍGUEZ VÁZQUEZ et al., 1998)(ALVES & DEANA, 2010).

Some authors consider discomallear ligament as part of AML (BURCH, 1966)(TOLEDO FILHO, ZORZETTO, & NAVARRO, 1985)(CESARIANI, TOMBOLINI, FAGNANI, & DOMENECH MATEU, 1991), superior extension of the sphenomandibular ligament in the tympanic cavity (BURCH, 1966) or the "small ligament" described by Pinto in 1962 (PINTO, 1962). In contrast, other authors do not agree with the statement that AML and discomallear ligament are part of the same structure and say that there is a well-established difference between them (COLEMAN, 1970)(KOMORI, SUGISAKI, TANABE, & KATOH, 1986)(OGÜTCEN-

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TOLLER, 1995)(RODRÍGUEZ VÁZQUEZ et al., 1998)(Dai, Cheng, Wood, & Gan, 2007)(SENCIMEN et al., 2008).

Individuals with temporomandibular dysfunction may frequently exhibit otological symptoms. The dissonance of the stomatognathic system, such as muscular pain, TMJ pain, cervical pain, tooth sensitivity, joint noise and, in general, functional difficulties, were significantly associated with otologic symptoms in cases of temporomandibular disorders (FELICIO et al., 2004) (KITSOULIS, MARINI, ILIOU, GALANI, & ZIMPIS, 2011)(ÇAKUR & YAŞA, 2016).

The discomallear ligament presents mobility as it passes through petrotympanic fissure, caused by stretches in the TMJ disc during movements of the mandible (COULY & HUREAU, 1976)(CESARIANI et al., 1991)(SATO, ARAI, IMURA, KAWAI, & YOSUE, 2008)(ARAI & SATO, 2012). Consequently, it is believed that the mobility of this ligament according to the degree of closure of petrotympanic fissure determined during development may affect the movement of the middle ear bones (RODRÍGUEZ VÁZQUEZ et al., 1998). Some authors state that malleus mobility was observed when the discomallear ligament was overloaded (IOANNIDES & HOOGLAND, 1983)(O'RAHILLY & GARDNER, 1976)(PINTO, 1962)(TOLEDO FILHO et al., 1985). Nonetheless, other authors say that there is no evidence that discomallear ligament can cause movement of this ossicle chain (COLEMAN, 1970)(KOMORI et al., 1986)(LOUGHNER, LARKIN, & MAHAN, 1989)(ECKERDAL, 1991)(OGÜTCEN-TOLLER, 1995)(SENCIMEN et al., 2008).

The morphological characteristics of the ligament as well as its mobility may influence the movement of the malleus. This observation could strengthen the hypothesis of origin of pain in TMJ and of otalgia's (IOANNIDES & HOOGLAND, 1983)(RODRÍGUEZ VÁZQUEZ et al., 1998)(SATO et al., 2008)(SENCIMEN et al., 2008). Some authors have made a relation between the ligament in question and certain otologic manifestations caused by temporomandibular disorders (IOANNIDES & HOOGLAND, 1983)(Rohlin, Westesson, & Eriksson, 1985)(LOUGHNER et al., 1989)(OGÜTCEN-TOLLER & JUNIPER, 1993). Tinnitus may be due to the transmission of excessive mechanical forces by discomallear ligament (PEKKAN, AKSOY, Hekimoglu, & Oghan, 2010)(RAMÍREZ ARISTEGUIETA et al., 2009)(ASH, ASH, ASH, & ASH, 1990). It may also be a possible pathway for the spread of infection from the middle ear to temporomandibular joint, such as otitis media, which can, through petrotympanic fissure, cause capsulitis or even rupture of the ossicle joint (LOUGHNER et al., 1989). In contrast, other authors say that the ligament has no role in otological manifestations (CHEYNET et al., 2003)(ALVES & DEANA, 2010), because it does not contain sufficient force to mobilize the bones of the middle ear once it is firmly adhered to petrotympanic fissure (ALVES & DEANA, 2010).

V. CONCLUSION

For this purpose, that the methods evaluated and the studies analyzed show the anatomical relationship between the tympanic cavity and the temporomandibular joint, as well as the existence of the discomallear ligament and its possible influence on the otologic symptoms caused by temporomandibular disorders.

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