HUMAN TEMPOROMANDIBULAR JOINT DISC: ANATOMY AND MEASUREMENTS IN PRENATAL DEVELOPMENT

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ABSTRACT

The objective of this study was to determine morphological characteristics and measurements of the temporomandibular joint (TMJ) disc in human fetuses between 16 and 20 weeks of intrauterine life, and correlate it with oral-facial neuro-muscular maturing.

Scanner images were used to record the length of the disc (D) and the thickness of its anterior, middle and posterior bands in TMJ anteroposterior vertical sections from human fetuses of 16, 18 and 20 weeks of intrauterine life (WIL).

Mean disc length was 1.98 mm, 2.69 mm and 2.90 mm at 16, 18 and 20 WIL respectively, and measurements differed significantly between those ages. The thicknesses of the anterior, middle and posterior bands also differed significantly. The results give normal morphological data for D between 16 and 20 WIL. TMJ anatomy and measurements appear to be related and agree with the neuro-muscular maturation time at which sucking and swallowing reflexes begin before birth. It is known that these functions, as well as the neuro-muscular capacity to perform prenatal mandibular movements (opening and closing), begin at 14 to 15 weeks of prenatal development and are fully attained at about 20 weeks of development. Knowledge of this reference pattern may be of major importance to future research, for assessing jaw biomechanics and detecting alterations of TMJ and prenatal development of a vital human function – suckling in preterm infants.

Key words: temporomandibular joint disc, Morphology, embryonic development.

DISCO DE LA ARTICULACIÓN TÉMPOROMANDIBULAR HUMANA: ESTUDIO MORFODIMENSIONAL EN PERÍODO PRENATAL

RESUMEN

El objetivo de este estudio fue determinar las características morfológicas y dimensionales del disco de la articulación temporomandibular (ATM) de fetos humanos entre las 16 y 20 semanas de vida intrauterina y correlacionarla con la maduración neuro-muscular buco-facial.

Mediante un analizador de imágenes se registró la longitud sagittal, el espesor de las bandas anterior, media y posterior del disco (D) en corte vertical ánteroposterior de ATM de fetos humanos de 16, 18 y 20 semanas de vida intrauterina (SVI). La longitud promedio del disco fue de 1.98mm, 2.69mm y 2.90mm a las 16, 18 y 20 SVI respectivamente, encontrándose diferencias dimensionales significativas entre aquellas edades. También los espesores anterior, intermedio y posterior de las bandas mostraron diferencias significativas entre los D de las edades estudiadas. Los resultados proporcionan datos morfológicos normales del D entre las 16 y 20 SVI. Los parámetros anatómicos y dimensionales de la ATM encontrados, estarían relacionados y coinciden con el tiempo de maduración neuro-muscular en el cual se inician los actos reflejos de succión y deglución previa al nacimiento. Como es conocido aquellas funciones se inician entre las 14 o 15 semanas de gestación, así como la capacidad neuro-muscular para realizar los movimientos mandibulares prenatales (apertura y cierre) que se alcanzarían alrededor de las 20 semanas de desarrollo.

El conocimiento de éste patrón de referencia puede ser de gran importancia para futuras investigaciones, para valorar la biomecánica mandibular y permitir reconocer alteraciones de la ATM y del desarrollo prenatal en una de las funciones vitales del ser humano, como es la lactancia en recién nacidos prematuros.

Palabras clave: Disco de la articulación témporomandibular, morfología, desarrollo embriológico.

INTRODUCTION

The temporomandibular joint (TMJ) is one of the most complex joints in the human body. It connects the jaw to the cranium, enabling the jaw to move and fulfill a vital human function: suckling and feeding in newborn infants. Its alteration involves nutritional, neurological, sensorial, immunological and affective deficiencies, and affects normal oral-maxillofacial development. Early detection of dysfunctions that alter or prevent vital functions in the newborn infant is therefore needed in order to prevent these growth and development disorders[1, 2]. Many newborn infants do not start suckling, or do so in an uncoordinated, deficient way, due to various etiologies. There are many factors that may prevent a newborn infant from latching on to the nipple (breast or bottle), such as oral-maxillofacial anatomical and functional alterations, metabolic or central nervous system alterations and some first arch syndromes[2-9].

Knowledge of the histology, anatomy and measurements of the TMJ, including embryological development, provides significant support to the understanding of the etiopathogenesis and physiopathogenesis of damaging dysfunctions. The subject has therefore been studied by many researchers, particularly from physiological and clinical standpoints, mainly during the post-natal period in humans[3, 9-11]. The morphology and measurements of the articular disc (D) during prenatal development have not been described in available literature, nor has a pattern of normality been determined for the articular disc during the prenatal stage. The formation of the articular disc is identified at the end of the embryonic period (twelve weeks). It develops from both blastemas – condylar and glenoid – (upper and lower portions of the disc respectively) showing its close relationship to the superior lateral pterygoid muscle and Meckel's cartilage which gives rise to the malleus[10,12].

It has been suggested that the oral-facial neuromuscular maturation needed for acquiring the sucking and swallowing reflexes before birth begins at 14 or 15 weeks gestation and is complete at about 20 weeks[4,13]. The formation and maturation of the condylar process at the expense of the secondary cartilage (condylar cartilage) and the neuromuscular capacity to perform the prenatal mandibular movements (opening and closing) are probably attained at approximately 20 weeks of development. Both mechanisms are essential to the development of reflex actions for feeding[14,15].

It should be noted that there is partial or global alteration of these functions in preterm infants, depending directly on gestational age[1,6,7]. Thus, these biomechanical functions may be altered in full-term and/or preterm infants.

Based on this background, it could be determined whether TMJ anatomy and measurements are correlated to embryonic age, specifically, whether the TMJ is prepared for the biomechanical movement that results from the sucking and swallowing reflexes beginning approximately at the abovementioned age. This would allow resulting alterations to be identified, rehabilitated and/or prevented.

MATERIALS AND METHODS

For the study of articular disc morphology and measurements, human fetuses fixed in 10% formalin were used (without apparent macroscopic anomalies), at gestational ages of 16, 18 and 20 weeks. These fetuses were from spontaneous abortions and were provided by the anatomic pathology service at Hospital Materno Neonatal (Ministry of Health of Córdoba Province, Argentina), unclaimed by their progenitors, with legal authorization for use in study purposes at the abovementioned service.

Gestational age was determined for each specimen according to cephalocaudal length (Fig. 1), using the human development table[16] (Table 1).

To dissect the TMJ area, a vertical preauricular incision was made between an upper semicircular, concave-up incision and a lower horizontal incision following the lower edge of the mandibular branch and body (Fig. 2).

Table 1: Criterion for calculating gestational age – (Keith L. Moore, Clinical Embryology).

Age (weeks)	Crown-rump length (mm)	Age (weeks)	Crown-rump length (mm)
8	40	22	210
9	50	24	230
10	61	26	250
12	87	28	270
14	120	30	280
16	140	32	300
18	160	36	340
20	190	38	360

Fig. 1: Fetus, gestational age 16 weeks. Cephalocaudal length 155 mm.

The skin and subcutaneous cellular tissue were peeled back to expose the temporal and masseter muscles, which were also dissected to the articular capsule, but without touching it. At 1.5 centimeters peripheral to the TMJ, a cut at a depth of approximately 2 cm was performed above, below, in front of and behind it. The block was then moved in order to reach and release its medial wall using scissors, and finally the complete joint was removed as a block (articular eminence and temporal mandibular or articular fossa, mandibular condyle and all components of the soft tissues), fixed in 10% formalin and labeled (Fig. 3). A scalpel was then used to make an anteroposterior vertical cut (Fig. 4) under a stereoscopic microscope, beside and parallel to the squama temporalis, just above the superior wall of the joint where the zygomatic process begins, thus standardizing the sections so that they would be reproducible and errors minimized (Fig. 4). It is important to note that in fetuses and infants the mandibular fossa is not placed horizontally, but obliquely, running from lateral to medial and superior to inferior.

All samples were examined under stereoscopic microscope at 2x magnification. Screening criteria were having an undamaged bilaminar zone, and a sharp, clear image of the anterior edge of the section and its three bands, with no tears. Samples should be precise enough for the anterior and posterior edges of the disc (D) and the edges of each band thickness to be seen clearly. The anterior edge was taken as the vertex of the angle formed by the bifurcation of the anterior capsule fibers. The posterior edge was taken as the vertex of the angle formed by the bifurcation of the bilaminar area (Fig. 5).

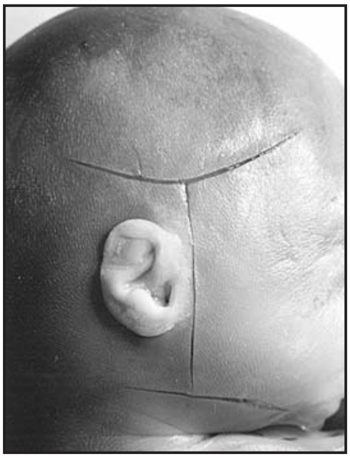

Fig. 2: Lateral view of head of fetus, gestational age 16 weeks, on which an H-shaped incision has been made to reach the temporal, masseter and TMJ regions.

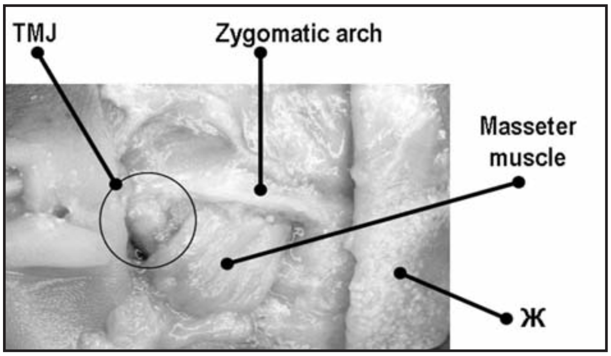

Fig. 3: Front, right of figure: cutaneous and subcutaneous tissues (Ж) peeled back, allowing view and access to temporal, masseter and articular (TMJ) regions.

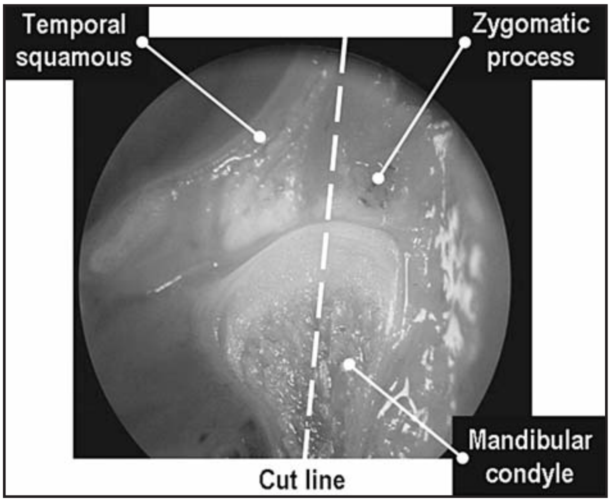

Fig. 4: Picture of a frontal section of TMJ from a fetus 18 WIL, showing the vertical anteroposterior cut line (dotted line – cut line) that the sections were cut along for the morphological study of the articular disc. The right side of the figure is the medial side, and the left is the lateral.

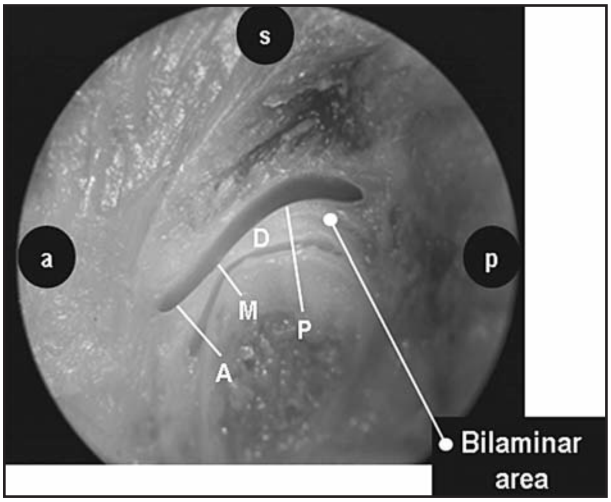

Fig. 5: Vertical anteroposterior section of TMJ. Accurate sectioning of the sample allowed the following to be identified and recorded: (D: disc; A: anterior band; M: middle band; P: posterior band; s: superior; a: anterior; p: posterior) (fetus 18 WIL).

Two samples were taken from each of the 36 fetuses in the sampling universe, adding up to 72. They were documented with digital photographs at 2x magnification under a stereoscopic microscope, and only 36 samples (one from each fetus) were selected for the corresponding analysis of measurements according to the aims established in the study. The same stereoscopic microscope was used to make a digital image of a millimeter caliper gage to be used as a reference for measurements.

The images were processed with special software (Image Pro-Plus) for different types of measuring. A measurement pattern was created, according to which all the measurements of the anatomical samples were recorded; following exactly the same sequence to ensure it was reproducible and to evaluate all samples under the same conditions, thus minimizing the margin of error.

The measurements considered for the study were: 1: length of articular disc, for which the image processor was used to draw an anteroposterior line between the anterior and posterior edges described above, maintaining equal distance from the upper and lower edges, 2: the anterior band of the disc was measured from its upper to its lower edge in a line perpendicular to the one drawn to measure its length, and the software determined its thickest part, 3: the middle band was measured in the same way but the software determined the thinnest part, and 4: the posterior band, in the same way as the others, at its thickest part.

The samples were grouped according to different gestational ages (Table 2). Group I (GI): was made up of 9 (nine) TMJ samples from fetuses at 16 weeks of intrauterine life (WIL). Group II (GII): made up of 12 (twelve) TMJ samples from fetuses at 18 WIL, and Group III (GIII): made up of 15 (fifteen) TMJ samples from fetuses at 20 WIL.

RESULTS

The aim of analyzing the morphometric data of the articular disc was to relate the different measurements at the three gestational ages.

The results from the 36 samples that were selected and processed are shown in Tables 3, 4, 5, 6, Fig. 6. The data showed homoscedasticty (homogeneity of variance, i.e. the variability in the response in each specimen is almost the same between samples) and normality, so an analysis of variance test (ANOVA) considering statistically significant differences with a value $p<0.05$ was performed for each characteristic (length of disc and thickness of anterior, middle and posterior bands).

For all measurements, statistically significant differences were found when GII and GIII were compared to GI. There was no difference between the

Table 2: Groups according to gestational age.

	Gestational ages	Number of samples
GROUP I	16 weeks intrauterine life (WIL)	9
GROUP II	18 weeks intrauterine life (WIL)	12
GROUP III	20 weeks intrauterine life (WIL)	15
		Total: 36

Table 3: Comparison of anterior band thickness in the three groups.

Test: Fisher's LSD Alpha: = 0.05 - MSD: = 0.10849 Error: 0.0167 df: 33

ID	Means	number of samples	
GI	0.32	9	A
GII	0.50	12	B
GIII	0.50	15	B

Different letters indicate significant differences (p<= 0.05) (MSD: mean standard deviation; ID: study group identification).

Table 4: Comparison of middle band thickness in the three groups.

Test: Fisher's LSD Alpha: = 0.05 - MSD: = 0.04302 Error: 0.0026 df: 33

ID	Means	number of samples	
GI	0.06	9	A
GII	0.13	12	B
GIII	0.14	15	B

Different letters indicate significant differences (p<= 0.05) (MSD: mean standard deviation; ID: study group identification).

Table 5: Comparison of posterior band thickness in the three groups.

Test: Fisher's LSD Alpha: = 0.05 - MSD: = 0.15473 Error: 0.0340 df: 33

ID	Means	number of samples	
GI	0.51	9	A
GII	0.71	12	B
GIII	0.75	15	B

Different letters indicate significant differences (p<= 0.05) (MSD: mean standard deviation; ID: study group identification).

two latter times (GII and GIII, i.e. between 18 and 20 weeks gestation).

Figure 6 shows the arithmetical mean values of each measurement of the articular disc for the three age groups and relationship between median and the values that are not among the most frequent (but not rare). Table 7 summarizes the results for the different groups.

Table 6: Comparison of disc length in the three groups.

Test: Fisher's LSD Alpha: = 0.05 - MSD: = 0.43488 Error: 0.2683 df: 33

ID	Means	number of samples	
GI	1.98	9	A
GII	2.69	12	B
GIII	2.90	15	B

Different letters indicate significant differences (p<= 0.05) (MSD: mean standard deviation; ID: study group identification).

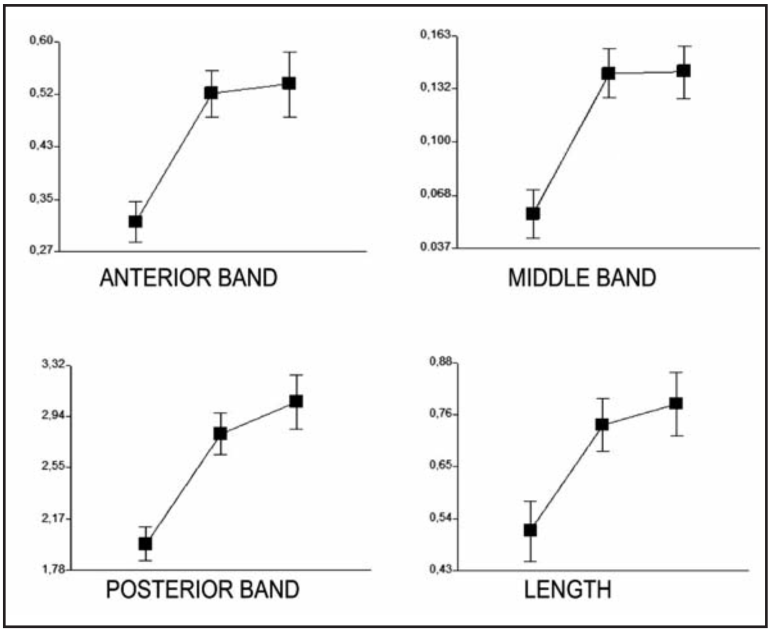

Fig. 6: Mean value and standard deviation for each measurement of the articular disc in the three age groups.

DISCUSSION

On the sagittal plane, according to its thickness, the articular disc is divided into three bands[17, 18]. There is noticeable similarity between the thickness values at 18 and 20 WIL for the anterior and middle bands, interpreted as a plateau in growth during that stage of development, at least regarding the TMJ disc. On the coronal plane, in adults there is a disc eminence on the superior face and posterior band of the disc[18], which is not present on the disc of 16 to 20 WIL fetuses (Fig. 5) because the function of the jaw is also different, joint movements that are generated by the action of associated muscles of mastication and driven and coordinated by the nervous system [19-22]. In other words, the joint biomechanics at five months' development does not require the morphological configuration of an adult.

When a fetus and/or preterm or full-term infant performs sucking action, the mandibular condyle moves with the disc in posterior-anterior direction without any modification of the route from the mandibular fossa (MF) to the articular eminence (AE), which are almost flat in sagittal direction. In other words, the topography of the TMJ is directly related to the presence or absence of teeth and the mandibular function, and there is correlation between gestational age and the start of biomechanics, driven by sucking and swallowing reflexes in the embryonic stage at 20 WIL. Further research monitoring the mandibular/articular movement at that age, possibly during pregnancy, by means of ultrasonography, would complement this study.

Knowledge of joint morphology and biomechanics at 20 WIL and in infants would allow alterations of TMJ and its associated structures to be identified,

Table 7: Measurements of the articular disc of the temporomandibular joint in human fetuses.

Age group	*Gestational age*	*Average length of disc in millimeters*	*Thickness of anterior band of the disc in millimeters*	*Thickness of middle band in millimeters*	*Thickness of posterior band in millimeters*
I	16 WIL	1.98	0.32	0.06	0.51
II	18 WIL	2.69	0.50	0.13	0.71
III	20 WIL	2.90	0.50	0.14	0.75

Comparison of average measurements of the articular disc in the three groups studied. Note that the average thickness of the anterior band is the same at 18 and 20 WIL, and that there is little difference between the thickness of the intermediate band of the disc at 18 and 20 WIL.

preventing future dysfunction and post-natal anomalies in growth and development, and the implementation of appropriate therapies, enabling the infant to feed normally again. This means that it is important to include a dentist in the interdisciplinary health team so that in case of a joint disease, specific, biologically adequate treatment may be provided.

To sum up, the measurements of the disc at 16, 18 and 20 WIL are significant in that they would allow pre-natal diagnosis of future TMJ alterations.

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