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ORIGINAL ARTICLE

# Manubriosternal joint: synchondrosis or symphysis? Analysis of morphology and aging in humans

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## Abstract

**Introduction** The uncertainty about the morphological classification of the manubriosternal joint is historical in the field of Anatomy and is still under discussion. This makes it difficult to teach and diagnosing related matters, especially those that require radiological images. In fact, this subject lacks specific data.

**Purpose** This study aims to describe the morphology of the manubriosternal joint and its age-related changes.

**Methods** Thirty specimens were divided in three groups: young adults up to 35 years of age, middle-aged adults ranging from 36 to 55, and older adults over 56 years. The subjects were labeled, and blind analysis were performed using the macroscopic and microscopic analysis.

**Results** The large presence of isolated fibroblasts and chondrocytes and the lower degree of isogenic groups proved that the manubriosternal joint is a symphysis. Its age-related changes involve the reduction of thickness and hydrated characteristics, loss of uniformity and arrangement of the collagen fibers, hyalinization and the presence of focal lesions, that corroborate with the degenerative process.

**Conclusion** The manubriosternal joint is classified as symphysis and the main age-related changes is the relative thickness of the tissue.

**Keywords** Manubriosternal joint · Symphysis · Synchondrosis · Joint · Cartilage

## Introduction

The manubriosternal joint is the articulation between the manubrium and the body of sternum [1, 2]. Its morphological classification diverges in literature; this joint is commonly classified by clinicians as synchondrosis [3–6], although most anatomists identify it as symphysis [7, 8]. Morphological features such as ankylosis and proliferative changes in the cortical bone (osteophyte and sclerosis) are also documented [9, 10]. Some degree of synostosis has also been identified and associated as age-related change [9–11]. All these characteristics of the manubriosternal joint make the radiological diagnosis, the therapy and the functional analysis of the thorax an arduous task [9, 12]. Despite the substantial development in medical research, this subject remains incipient.

The aim of this study is to identify in which morphological classification the manubriosternal joint belongs to, as well as to understand its age-related changes.

## Materials and methods

### Specimens

This study was approved by the Research Ethics Committee (reference 732.797). The manubriosternal joints were obtained from the Coroner's Office of Victoria, Brazil. The exclusion criteria were trauma, surgery, scars and tattoos in the region of interest, as well as rheumatoid disease record.

Thirty manubriosternal joints were extracted from subjects aged 15–91 years old. The joints verified as ossified were properly documented and excluded from other stages of the methodology.

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For the mere description of results, the subjects were divided into three groups: young adults (YA), middle-aged adults (MA) and older adults (OA) [13]—Table 1.

### Macroscopic analysis

The subjects were labeled with a random number and blind tests were performed with the researcher involved in the macroscopic and microscopic analysis. After the findings were recorded, the specimens age was revealed and the findings were correlated.

The stereomicroscope was used to describe the manubriosternal joint macroscopically and qualitatively at the Laboratory of Applied Morphology—LEMA (Stemi2000C and AxioVision image analysis software, Zeiss, Germany). This analysis aimed at understanding the morphological characteristics of the joint (hyaline material, and fibrous, rough and mucinous tissue), focal lesions (sclerosis, breaks, sections or cracks) and general aspects such as uniformity and thickness. Holding such results, the specimens were fixed in buffered formalin for at least 72 h and followed a decalcification protocol of 48 h under 5% nitric acid.

### Microscopic analysis

Only the right part of the joint was dehydrated over a gradient of alcohols (70–100) and xylene (3x) for further incubation in paraffin and semi-serial sagittal slices at 7 µm. The slices were processed according to histological routine and stained with hematoxylin and eosin (HE), and Mallory Trichrome [14].

Microscopic analysis (LEMA—Primo Star and AxioVision image analysis software, Zeiss, Germany) were established in a qualitative manner enabling the investigation of hyaline characteristics, the tissue arrangement, degenerative aspects, the collagen density and/or elastic fibers, the density of chondrocytes or isogenous groups, the density of fibroblasts and extracellular matrix.

## Results and discussion

The manubriosternal joint still raises questions about its morphology and aging. No works have been found in the literature that could serve as a basis for methodology or delineate thorough discussions on the age-related changes. Thus, our specimens were designed to approach young adults, middle-aged adults and older adults [13] to establish comparisons regarding the age and morphology of the joint. Those 26 specimens along with the 76-year age group variation constituted the novelty of this work.

Cameron and Fornasier [2] studied over 600 radiographs of the manubriosternal region and found 14% of calcification among their samples, which was very similar to our findings (13.3%, four cases) [9]. The authors considered the finding as synostosis, and regardless of the similar data, they did not correlate it to the presence of previous rheumatic diseases. In fact, the complete fusion of the manubriosternal joint varies in the literature. Despite the absence of experiments, some authors confirm that the joint ossifies in the third decade of life [7, 15]. However, our results cannot agree with that; the youngest specimen identified with synostosis was 50 years old, and the others were 61, 66 and 91 years old. Although the sternum growth is well known to be finished at age 30 [16], we believe that the synostosis is not related to a specific age [9].

The macroscopic analysis of the YA demonstrated a clear, uniform and whitish aspect, indicating hydration of the structure. The occurrence of cracks was not unusual in this group, although the hydrated characteristic was the standard (Fig. 1a). The OA group featured clear degenerative characteristics: fissures, focal lesions or nodes, decreased joint thickness, loss of structural uniformity and stronger yellowish stains compared to the ones seen in YA, indicating a calcification process (Fig. 1c). Nevertheless, it was possible to verify how the morphology modifies from YA to OA in the MA group, which showed the loss of structural uniformity, small nodes or cracks and yellow shade variations, indicating a decrease in hydration. However, the MA seems to have its morphology more similar to the YA (Fig. 1b).

Under a single macroscopic analysis, it was not possible to describe the manubriosternal joint as a symphysis, even though it was possible to notice a hyaline layer covering the

**Table 1** Specimens and age groups

| Group | Age (years) | Specimens | Excluded (ossification) | Final no. of specimens |
|---|---|---|---|---|
| YA | < 35 | 3 = 2 Female and 1 male | – | $n = 3$ |
| MA | 36–55 | 5 = 3 Female and 2 male | One male | $n = 4$ |
| OA | > 56 | 22 = 9 Female and 13 male | Two male and one female | $n = 19$ |


**Fig. 1** Photographs of human manubriosternal joints of young adults (**a**), middle-aged adults (**b**) and older adults (**c**). Note the progressive loss of uniformity, hydration and thickness in the joints among the groups. Scale bar 2 mm

articular surface of the manubrium and the body of sternum [17] (Fig. 1) in all specimens. This justifies the current discussion and divergences between authors in anatomy [1, 2, 7, 18] and clinical fields [3–6].

The microscopic study of YA exposed a large presence of isolated fibroblasts and chondrocytes, as well as a lower degree of isogenic groups. The fibrous connective tissue and collagen fibers were organized, and in some regions were similar to lamellae (Fig. 2a), while the extracellular matrix was homogeneous. These aspects characterized the manubriosternal joint as a symphysis [19].

The MA presented a relatively higher amount of isogenous groups, less isolated and hypertrophic chondrocytes (Fig. 2b), reduction of the collagen arrangement and a

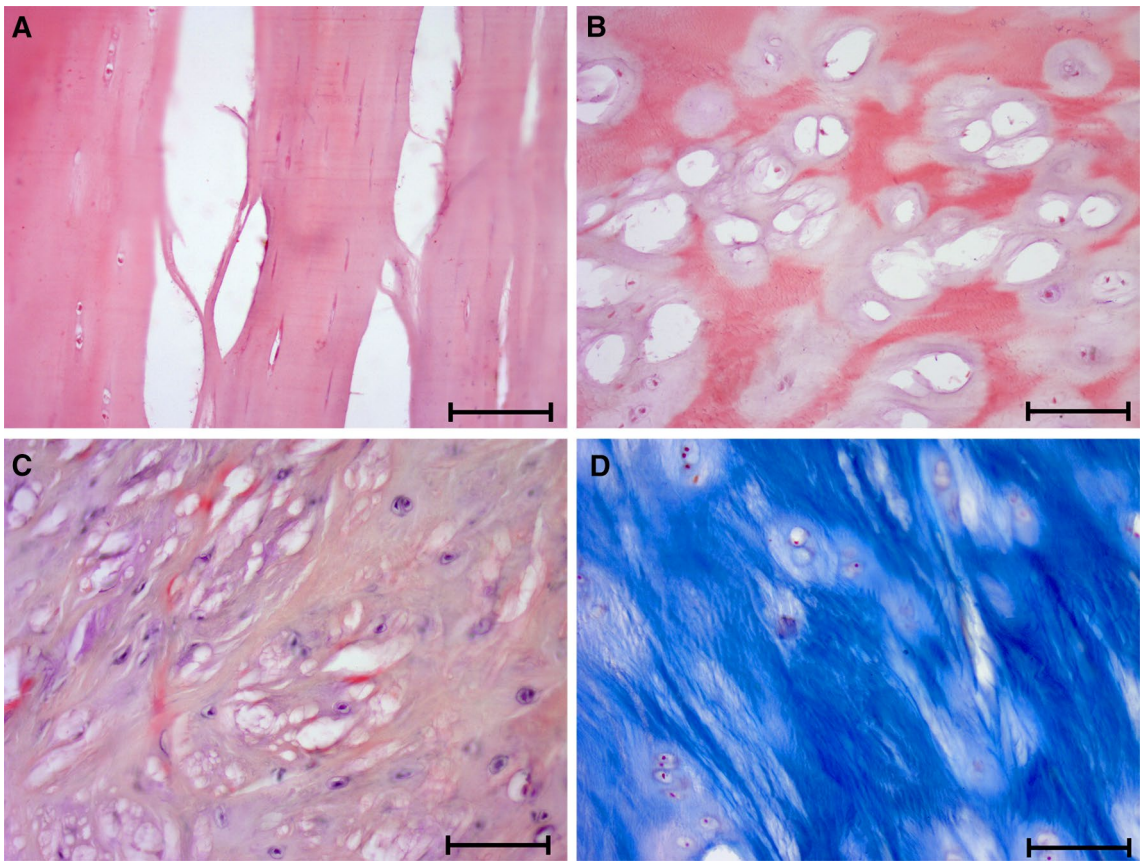


**Fig. 2** Photomicrographs of histological slices of the human manubriosternal joint. **a** Young adults, hematoxylin and eosin. **b** Middle-age adults, hematoxylin and eosin. **c** Older adults, hematoxylin and eosin. **d** Older adults, Mallory trichrome. Note the fibroblasts at the center of the image in **a**, and the interconnected lamellae organization of the fibrous tissue. Visualize the isogenic groups formation and the increase of the extracellular matrix in **b**. Observe the loss of the fibrous tissue arrangement in **c** and **d** and the isolated chondrocytes in **d**. Scale bar 100 µm

relative increase of the extracellular matrix in relation to the number of cells (Fig. 2b, c, e). These aspects suggest degeneration, and a very similar process is already extensively documented in the intervertebral disc studies [20, 21]. In fact, Cameron and Fornasier [2] had already identified the relationship between thoracolumbar disc degeneration and manubriosternal abnormality.

Despite the increase in the extracellular matrix, a large amount of isogenic groups were seen in the hyaline layers. The disorganization and extinction of the collagen lamellae were only visualized in OA, corroborating, to the author's knowledge, the only experimental study found in the literature [22].

The results allowed classifying the joint as symphysis, therefore, it is no longer appropriate to assert that the manubriosternal joint is a synchondrosis as some clinicians would [3–6]. This result is congruent with the literature [1, 2, 7, 12, 22].

The microscopic variations between the groups, especially the increase of the thickness of the peripheral hyaline layer and decrease of the collagen arrangement in OA, may raise hesitation to confirm that the manubriosternal joint is a symphysis. The clear finding of organized fibrous connective tissue and fibroblasts in the YA and MA was determinant in this analysis. It can be assumed that with age this joint goes through a degeneration process and subsequent endochondral ossification, according to the hypotheses of other authors [7, 9, 12].

Our research elucidates the type of tissue between the manubrium and the body of sternum, which has arisen much debate in the field of anatomy throughout the years without, from the authors' perspective, thorough research. We can also assert that the variations of the joint within the age groups is useful for surgical management [23, 24] and differential diagnosis in radiology examinations of degenerative joint diseases [10]. The decrease in thickness or the occurrence of sclerosis or synostosis is not necessarily a sign of osteoarthritis of the manubriosternal joint as degenerative features are part of the age-related change.

The functional implication of this joint is in breathing, and this topic has also been discussed in the literature [9]. We agree with the idea that the synostosis does not affect breathing due to the type of movement (bucket-handle), even in the rare condition of luxation of the sternum with the maintenance of deformity in adult thorax [25]. On the other hand, in cases of subluxation of this joint in children, whose chests are more resilient than adults' [15], it can be agreed that the painful breathing results in reduction of respiratory capacity [26].

## Conclusion

The manubriosternal joint is classified as symphysis, characterized by the presence of fibroblasts, by the organized arrangement of fibrous tissue and collagen fibers, and containing bone surfaces covered by hyaline cartilage. This joint may undergo a degenerative process that, with age, can evolve to synostosis. The main age-related changes are the relative thickness of the tissue, the amount of isogenic groups, the collagen fiber arrangement and the extracellular matrix ratio.

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**Author contributions** JM Sarcinelli: project development and data collection. R Eustáquio-Silva: project conception and manuscript writing/editing. JS Baptista: project development, data analysis and manuscript writing/editing.

### Compliance with ethical standards

**Conflict of interest** The authors declare no conflicts of interest.

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