Compressive Mechanical Force's Effect on Temporomandibular Joint's Cartilage: a Systematic Review

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INTRODUCTION

Mechanical loading is essential for the maintenance of chondrocyte proliferation and extracellular matrix production of temporomandibular joint's (TMJ) fibrocartilage. [1] Nonetheless, abnormal and excessive loading might disrupt this homeostasis, affecting the functional integrity, and resulting in damage to the fibrocartilage. [2]
Changes in fibrocartilage morphology and cellular content and arrangement can compromise the normal and healthy function of TMJ, resulting in degenerative joint disease (DJD). [1,3]
An example with clinical relevance of these diseases is temporomandibular joint osteoarthritis (TMJ OA), a progressive degenerative disease that affects the hard and soft tissues of TMJ. It is characterized by cartilage thinning, extracellular matrix degradation, and decreased number of chondrocytes. [3,4]
Having a high prevalence and a multifactorial etiology, it is important to study the potential causes of it, namely the excessive mechanical loading induced by compressive force. [3,4]

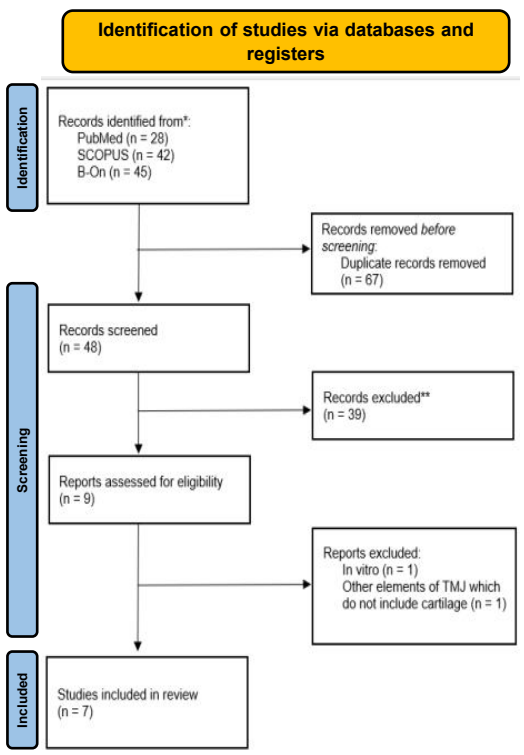
OBJECTIVES

This systematic review aims to evaluate the **morphological and cellular changes** in temporomandibular joint's **fibrocartilage** resulting from the **compressive mechanical force**, **in vivo**.

MATERIALS AND METHODS

A specific PICO question was formulated: **"What is the effect of compressive mechanical force in the temporomandibular joint's cartilage?".**
An electronic database search for articles published in PubMed, SCOPUS, and B-On was conducted until December 2021, using the following search strategy: **"temporomandibular joint"** AND **"cartilage"** AND "**compressive**".
After removing the duplicates, the remaining articles were screened by two independent calibrated reviewers.
Only **in vivo experimental studies that provided knowledge about the effect of compressive force in temporomandibular joint's fibrocartilage**, published in the **last ten years**, were included.
Studies regarding treatments for temporomandibular joint pathologies, or sex differences were excluded.

RESULTS



Fiq 1. PRISMA flow diagram for the identification and selection of elegible studies.

Study	Sample (Magnitude and duration of loading)		Main findings
Magara et al. 2012 [5]	**25 rats** 15 EG - 50g 10 CG	*5 days*	- ↓ **thickness** - Acelular region in mature layer
Du et al. 2020 [6]	**12 mice** 6 EG - 40g 6 CG	*7 days*	- Appeared **thinner** - ↑ **IL-1β** and **MMP-3**
Huang et al. 2021 [7]	**44 rats** 22 EG- - 40g 22 CG	*7 days*	– ↓ **thickness** and **chondrocytes** – ↑ **TNF-a, IL-1β** and **IL-6**
Jiang et al. 2017 [8]	**48 rats** 2 X 12 EG - 40g 2 X 12 CG	*4 days* *7 days*	– ↓ **thickness** (43%= 4 days; 56%= 7 days) and **chondrocytes** (50%= 4 days; 61%= 7 days) – ↑ chondrocytes **apoptosis** in 4 days EG (82%); ↓ **TUNEL positive cells** were observed in 7 days EG – ↓ **Collagen II** (49%=7 days) and **X** (84%= 7 days) – ↑ **TNF-a** and **IL-1** in both EG
Zhang et al. 2021 [9]	**84 rats** 2 X 12 EG - 80g 2 X 12 CG	*4 days* *7 days*	– ↓ **LOXL2** (p>0.05= 4 days; p<0.05= 7 days) – ↓ **thickness** (190.46±11.32 μm= 4 days;142.83±11.74 μm= 7 days) – ↓ **proteoglycans** (33% =5 days; 77%= 7 days) – ↓ **collagen II** (p>0,05= 4 days; p<0,01= 7 days) – ↑ **TNF-a** (p<0,05= 4 days; p<0.05= 7 days)
Li et al. 2013 [10]	**64 rats** 4 X 8 EG - 40g 4 X 8 CG	*3 days* *7 days* *14 days* *21 days*	– 3 days: ↓ **cell order and arrangement**; ↓ **thickness**; ↑ chondrocytes **apoptosis** – 7 days: ↓↓ **thickness** ; ↓↓ **chondrocytes**; ↓↓ chondrocytes **apoptosis** – 14 days: ↓↓↓ **thickness** (2/3); ↓↓↓ **chondrocytes** (50%); ↓ **ECM amount**; ↓ **collagen II and X**; ↓ chondrocytes **apoptosis** – 21 days: ↑ **thickness**
Wen et al. 2016 [11]	**45 rats** 3 X 5 EG1 - 40g 3 X 5 EG2 - 80g 3 X 5 CG	*1 day* *3 days* *7 days*	– ↓ **thickness** (85% =1 day EG1, 70%=3 days EG1; <60%= 7 days EG1)(75%=1 day EG2; 65%=3 days EG2; <50%=7 days EG2) – ↓ **chondrocytes** (gradually in both EG) – **Apoptosis** was induced at day 1 and then **dropped quickly** in EG1, in EG2 apoptosis was **induced gradually with time** reaching its highest level at 7 days

Table 1. Characteristics of the included experimental studies (EG= Experimental Group- compressive force; CG= Control Group- no mechanical loading).

DISCUSSION

The experimental in vivo studies revealed that compressive mechanical force induces the **degradation of temporomandibular joint's fibrocartilage**, leading to pathological changes: reduction in cartilage thickness, lower number of chondrocytes, disorder and disarranged of cell layers, and increased expression of inflammatory factors.
These changes are **co-related with the time** and **magnitude** of loading, revealing that fibrocartilage has a **limited physiological tolerance**. Also, the effects are compatible with those of osteoarthritis.

CONCLUSIONS

Excessive compressive force is an important etiological factor of TMJ OA, enhancing the effects with the time and magnitude of loading.

CLINICAL RELEVANCE

Understanding how TMJ's fibrocartilage responds to compressive mechanical force might play an important role not only in the **treatment of TMJ disease, including osteoarthritis**, but also in **orthodontic treatments**.

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