THE ROLE OF PREDICTORS OF CARTILAGE DAMAGE PROGRESSION PREDICTORS TO TEMPORO-MANDIBULAR JOINT WHEN THE MANDIBULAR CONDYLE IS FRACTURED

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Abstract

Introduction. Pathology of the temporomandibular joint (TMJ) is one of the urgent problems of modern maxillofacial surgery. In the early stages following cartilage damage, the loss of proteoglycans and collagen mesh disorder leads to functional disorders and difficulties in daily life. The aim of the present work was to diagnose the damage to cartilage and bone components of TMJ in traumatic fractures of the mandibular condylar process (MCP), and to study the correlation of magnetic resonance imaging (MRI) results and biochemical parameters in dynamics. **Materials and methods.** 22 males with traumatic condylar fractures were considered for the study. All patients underwent MRI upon admission, for 30 and 180 days after the treatment. To study the degree of bone and cartilage damage of TMJ, the levels of pyridinoline (PID) and deoxypyridolin (DPID) were determined by fluorescent immunoassay in the urine samples of patients, both before the treatment and after 21, 30 and 180 days. **Results and discussion**. Upon admission after MRI, only 22.73±9.14% of the subjects showed damaged joint surfaces while, on the 30th day - 31.82 ± 10.16% and on the 180 day - 40.91±10.73%. Biochemical studies performed in the first days after injury showed an increased PID in all patients and increased levels of DPID in 20 patients, with average values of 150.82±10.73 and 37.00±2.22 nmol/mmol creatinine, respectively. **Conclusions.** MRI offers good analysis of all structures in joints, being able to detect damage to the articular cartilage only when present, and less suitable for detecting cartilage disorders as a disease stage, which precedes the lesion. Instead, tissue markers of PID and DPID bone destruction can be used to diagnose lesions of cartilage structures in very early stages and make predictions on the disease and its treatment.

Keywords: *condylar fractures, temporomandibular joint, bone and cartilage damage.*

1. INTRODUCTION

Pathology of the temporomandibular joint (TMJ) is one of the urgent problems of modern dentistry and maxillofacial surgery, being the third most common dental disease after caries and periodontal lesions [1,2]. A close topographic-anatomical and physiological connection of the mandible with the temporomandibular joint is obvious, so that the traumatic injuries of the mandible, such as fractures and contusions directly affect the condition of joint's articular surfaces and the structural elements, possibly causing persistent disorders. Previous clinical studies of ours [3] allowed us to identify and visualize, by means of MRI, and to confirm the following laboratory consequences of traumatic damage to the elements of TMJ: hemarthrosis, dislocation of a disk, deformation of a disk, adhesion of a disk, perforation of a disk, sprains of ligaments, rupture of ligaments, and damage of joint surfaces. All these complications can have a negative impact on further functioning of TMJ, in particular the development of inflammatory and degenerative-distrophic processes [4].

In the early stages after cartilage damage, the loss of proteoglycans and collagen mesh disorder lead to disruption of the matrix biomechanics, characterized by softening of tissues, articular cartilage, which, in turn, loses the ability to resist and transmit shock forces during physiological loading, which causes fibrillation and cracks [5], resulting in osteophytes formation, subchondral bone reconstruction and thickening of the joint capsule, while a prolonged loading of the damaged cartilage negatively affects the progression of the disease, eventually leading to general cartilage degeneration - all these appearing as biological

changes leading to functional disorders and difficulties in daily life [6].

A timely diagnosis of damage to temporomandibular joints, especially their cartilage, is a prerequisite for a successful treatment and helps improve prognosis in patients with joint diseases of different etiology. Various biochemical markers in blood or urine allow qualitative and quantitative assessment of the pathological process in the articular cartilage, and a number of indicators are viewed as predictors of the progression of joint damage [7]. According to many authors [8-10], markers of bone and cartilage tissue resorption, such as pyridinoline (PID) and deoxypyridinoline (DPID), which are cross-links between individual collagen molecules, have the highest diagnostic value. PID is mainly found in type II collagen in cartilages, ligaments and the like, while DPID - in type I bone collagen, playing a significant role in its stabilization. As a result of collagen resorption, PID and DPID are not metabolized in the body, but are excreted in the urine, so that the complex of PID and DPID can serve as a reliable marker of bone and cartilage destruction.

The aim of our work was to diagnose the damage to cartilage and bone components of TMJ in traumatic fractures of the mandibular condylar process (MCP) in early stages and to study the correlation of MRI results with the biochemical parameters in dynamics.

2. MATERIALS AND METHODS

22 male patients, aged 18-35 years, with traumatic fractures of the TMJ, hospitalized in the departments of maxillofacial surgery of Lviv Regional Clinical Hospital (LRCL) and Lviv Clinical Emergency Care Hospital (LCECH), were considered in the study. All patients had clinical symptoms of acute post-traumatic arthritis of TMJ: pain, swelling, limited mouth opening, and others. All patients underwent functionally stable osteosynthesis of MCP by titanium mini-plates, to ensure immobilization of the fragments of mandible and restore its anatomical integrity.

Upon admission, all patients underwent magnetic resonance imaging to assess the condition of the bone and myocardial elements of TMJ. During MRI examination of TMJ, a specially adapted coil was used to diagnose temporomandibular joints. Standard scanning was performed bilaterally in the following modes: PD, T1, T2 and STIR. The studies were performed upon admission to the hospital 30 and 180 days after treatment, depending on patients' complaints.

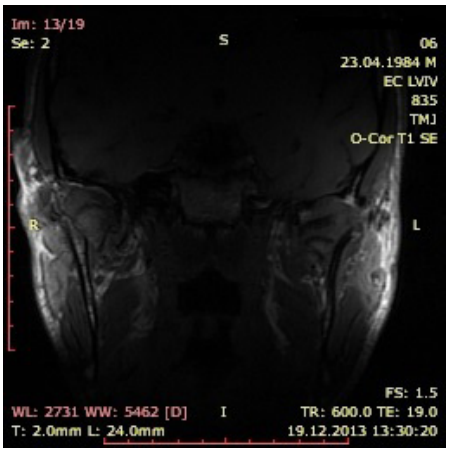
To study the degree of bone and cartilage damage of TMJ, the levels of pyridinoline (PID) and deoxypyridolin (DPID) were determined by enzyme-linked immunosorbent assay (ELISA method) in the urine samples of patients, both before the treatment and 21, 30 and 180 days after immobilization.

Instrumental and laboratory correlations were performed with general clinical examinations and patient complaints.

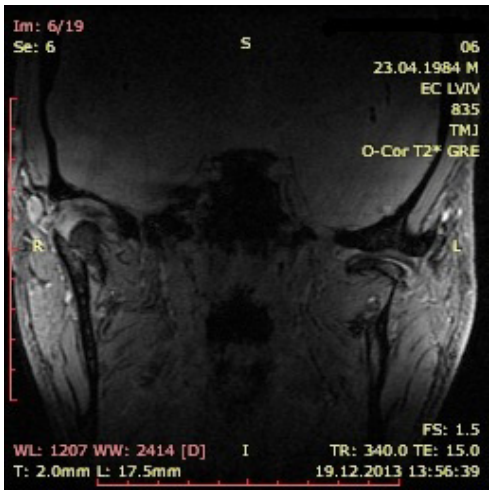
Mathematical and statistical processing of all obtained digital research results was performed using a personal computer with the appropriate software package «StatSoft Statistica 8». The arithmetic and relative values and their errors were determined. The mean values were compared using the Wilcoxon test.

3. RESULTS AND DISCUSSION

Using MRI diagnostics on a series of weighed images in the axial and coronal planes, the spatial location of the mandibular condyle with the presence of a high signal line about 1 mm thick, which clinically corresponds to the fracture line, was estimated. According to MRI data, only five individuals (22.73 ± 9.14%) were found to have damaged joint surfaces (Fig.1. A, B) in the study of MCC fractures.



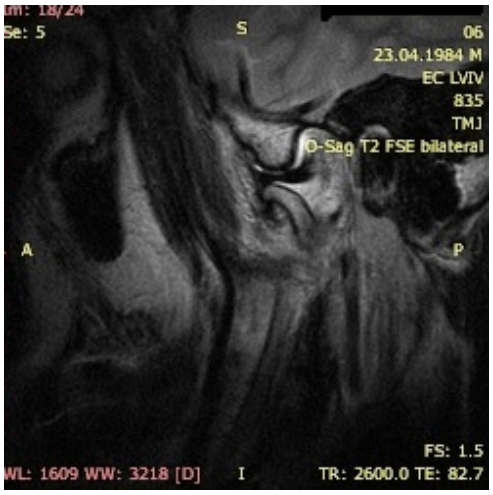
A



B

Fig. 1. A,B. in T1 and E2 * GRE weighted images in coronary projections: fracture of the head of the right condylar process and fracture of the neck of the left process with rotation of the distal fragment

In PD FSE mode, the subchondral-cartilage complex of the head of mandible (condyle) appeared as pronounced areas of dentition, thinning of articular cartilage, and reduction of weighed signals. On the 30th day, when the patients underwent control examination, the TMJ MRI study of seven patients (31.82 ± 10.16%) revealed signs of articular cartilage degradation with changed contours of the articular heads and decreased intensity in the subchondral areas (Fig. 2. A,B). Five patients who, upon admission, evidenced damage to the articular surfaces with cartilage lesions, did not show positive dynamics. The patients also complained of periodic pain of varying intensity in the area of the affected TMJ.



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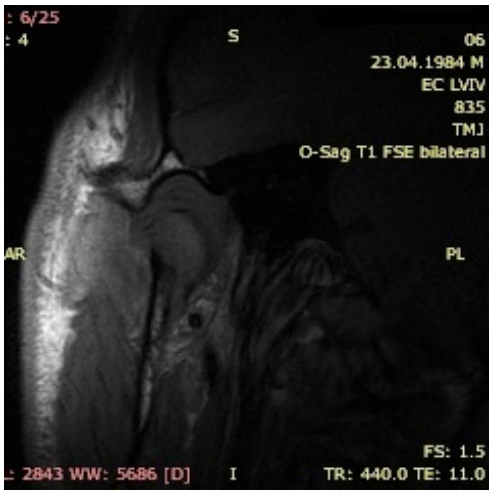

B

Fig. 2. A,B. In the area of the articular head, areas with hypo-intensive signals are visualized in T1, T2 weighted images, which indicate subchondral destruction

In the area of the articular head, zones with hypo-intensive signals are visualized in T1, T2 weighed images, which indicates subchondral destruction.

Clinical follow-up of patients after treatment for MCP fractures on the 180th day recorded complaints of pain in the TMJ area in 9 patients (40.91 ± 10.73%) who had a MRI scan. The scan results showed the homogeneity of the structure of the mandible branch and normalization of the signal at the site of the former fracture. However, in all nine patients (seven of whom had changes by the 30th day), a decreased intensity of the T1 signal, changed head contours and usuration, cartilage thinning in the area of the head to 0.2 mm and meniscus perforation were observed (Fig.3).

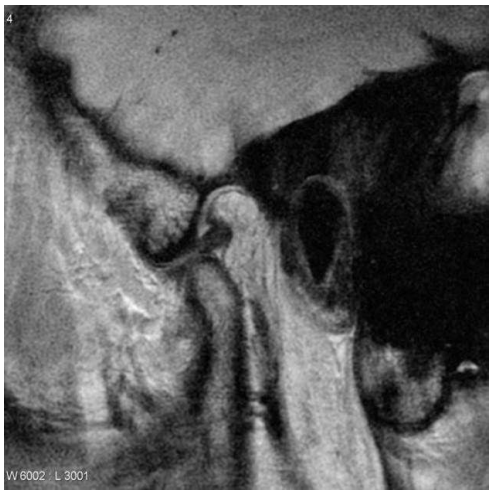

Fig.3. Perforation of the articular disc, damage to the subchondral complex of the TMJ head.

Analysis of MRI results shows that violation of the structure of bone and cartilage surfaces of TMJ in patients with MCP fractures in early stages can be observed only with significant mechanical tissue damage, as in 22.73 ± 9.14% cases established by us. However, dynamic observations suggested that one month after the injury, despite an adequate surgical treatment (functionally stable osteosynthesis), seven patients (31.82 ± 10.16%) continued and/ or developed subchondral cartilage complex destruction, available for visualization only 30 days after the injury. Our hypothesis about the damage and progression of the degradation of the TMJ cartilage structures during MCC traumatic fractures was confirmed when, by the 180th day, the number of patients with signs of lesions of the articular surfaces and changed cartilage structures had increased – nine patients (40.91 ± 10.73%). It is important that the MRI results were correlated with clinical indicators and patient complaints, such as recurrent pain, discomfort when opening the mouth, jaw deviation, morning stiffness, and the like.

The results of biochemical studies in the first days after injury (from 1 to 2 days) showed an increase in PID in all 22 patients and also in the level of DPID in 20 patients, with an average value up to 150.82 ± 10.73 nmol/ mmol and 37.00 ± 2.22 nmol/ mmol of creatinine, respectively (Table 1).

Table 1. Average values of PID and DPID at different times (M±m)

№ Patient	Creatinine **PID** (M±m) nmol/mmol				Creatinine **DPID** (M±m) nmol/mmol				Creatinine **NORM** nmol/mmol	
	Before	Day 21	Day 30	Day 180	Before	Day 21	Day 30	Day 180	PID	DPID
1.	**90**	60	56	58	**25**	18	19	17	**20-61**	**4-19**
2.	**210**	**202**	**166**	**158**	**47**	**46**	**42**	**34**		
3.	**120**	**116**	**110**	68	**33**	**29**	**28**	**20**		
4.	**150**	**142**	**139**	**87**	**38**	**36**	**34**	**23**		
5.	**180**	**168**	**154**	**157**	**44**	**41**	**38.5**	**39**		
6.	**195**	**178**	**165**	**158**	47	**43**	**41**	31		
7.	**100**	**90**	**78**	67	**25**	**22**	**19.5**	18		
8.	**120**	**104**	**96**	75	**30**	**25**	**24**	17		
9.	**240**	**215**	**188**	**178**	**54**	**52**	**47**	**45**		
10.	**88**	**84**	60	44	**22**	**21**	18.5	16		
11.	**166**	**141**	**122**	**73**	**42**	**37**	**30**	**22**		
12	**90**	60	56	58	**25**	18	19	15		
13	**210**	**202**	**166**	**152**	**47**	**46**	**42**	**34**		
14	**120**	**116**	**110**	66	**33**	**29**	**28**	**20**		
15	**150**	**142**	**139**	**141**	**38**	**36**	**34**	**33**		
16	**180**	**168**	**154**	**74**	**44**	**41**	**38.5**	**26**		
17	**195**	**178**	**165**	**162**	**47**	**43**	**41**	39		
18	**100**	**90**	**78**	47	**25**	**22**	**19.5**	19		
19	**120**	**104**	**96**	55	**30**	**25**	**24**	20		
20	**240**	**215**	**188**	**180**	**54**	**52**	**47**	**39**		
21	**88**	**84**	60	44	**22**	**21**	18.5	18		
22	**166**	**141**	**122**	**149**	**42**	**37**	**30**	**31**		
Total p<0.001	**150.82 ±10.73**	**136.36 ±10,50**	**121.27 ±9.40**	**102.32± 10.72**	**37.00± 2.22**	**33.64 ±2.36**	**31.05 ±2.12**	**26.18± 1.97**		

Twenty-one days after the treatment, the average level of PID and DPID decreased insignificantly - by 9.59% and 9.09%. Only two patients (9.09%) had normalized PID. On day 30, PID and DPID decreased by another 11.07% and, respectively, 7.70% value, but these rates came to normal in only 4 patients (18.18%). Six months later, the level of PID and DPID was 32.16% and 29.25%, respectively. PID rates were normalized in six patients - 27.27%, while DPID levels - in five (25%). A comparison of the average values of PID and DPID in patients before treatment and on the 21th, 30th and 180th day after the treatment, made using the Wilcoxon test, revealed statistically significant differences ($p < 0.001$).

The difference between the average values obtained in patients 30 days and 6 months after treatment was <0.01 when compared to PID and <0.001, respectively, when compared to DPID.

A comparative evaluation of MRI results and biochemical markers upon admission to hospital, *i.e.* in the first days after trauma, showed no direct correlation between these studies, since MRI recorded organic changes in only 5 patients, while increased PID and DPID levels were found in all 22 and, respectively, 20 patients. Therefore, we assert that it is impossible to visualize cartilage damage by the MRI method in very early or initial stage of the disease.

Comparing the biochemical parameters registered on the 30th day with the results of MRI, and taking into account the complaints of patients, a clear correlation of visualized signs of destruction of the TMJ bone and cartilage apparatus, and an increased level of markers of its destruction were established. Thus, all 7 patients who complained of TMJ functioning on the 30th day were found to have the highest levels of PID and DPID, while the changes in the chondro-ossal structure of the MCP head were confirmed on MRI, which is by 9.12% higher than diagnosed upon admission, although normalized biochemical parameters were observed only in 4 subjects.

When assessing the condition of patients six months after the injury, complaints and disorders (pain, chewing discomfort, deviation) of TMJ functioning were revealed in 9 patients, on the basis of which MRI was performed. The scan confirmed the destructive-degenerative signs of the TMJ bone and cartilage apparatus, which is by 17.36% higher than upon admission to the hospital and 8.24% more than the value revealed on the 30th day. This also indicates that, in 9 cases, the level of PID and DPID in urine was the highest, and normalization of biochemical parameters was observed in only 4 and 5 patients, respectively.

Given the close correlation of the general clinical, instrumental, radiographic and laboratory parameters, it can be assumed that 40.09% of the patients operated for traumatic MCP fractures develop chronic post-traumatic arthritis and/ or other temporomandibular disorders that require additional diagnosis, treatment and preventative measures.

Based on such analyses, it can be argued that modern MRI evaluation systems offer good investigation of all structures in joints, but they can detect damage to the articular cartilage only when it is actually present, which makes them less suitable for detecting cartilage disorders as a disease stage, which preceeding the lesion.

Instead, tissue markers of PID and DPID bone destruction can be used to diagnose lesions of cartilage structures in a very early stage, and make predictions on the disease and its treatment according to their changes.

4. CONCLUSIONS

The results of MRI for MCP fractures indicate organic changes in the structural elements of TMJ, both bone and soft tissue, but can only visualize their actual damage. Increased PID and DPID values confirm the destruction of both bone tissue and degradation of articular cartilage after traumatic fractures of the mandibular condylar process in the pre-radio diagnostics stage, that is, in the stage of development of the disease, which preceedes the focal changes. Correlation of the results of biochemical studies with MRI data was found, which corresponded to the clinical picture of post-traumatic arthritis or to other TMJ disorders. PID and DPID appear as tissue markers of bone and cartilage changes in TMJ in MCP fractures, and can be used as predictors of prognosis for joint destruction, as well as for disease progression. The absence of a

complete and timely normalization of PID and DPID values indicates the need to develop new treatment regimens for TMJ injuries, in order to prevent post-traumatic arthrosis and ankylosis.

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