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An investigation of mandibular asymmetries in patients with TMD as an element of the design of dental polymeric devices for early rehabilitation

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ABSTRACT

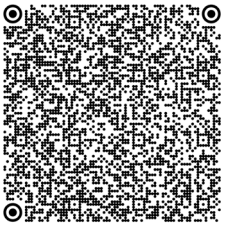
Purpose: It is essential to acquire data that will allow the detection of problems occurring within anatomical material structures before the appearance of obvious symptoms of TMD and to design materials and devices in order to take preventive measures. The aim was to examine if asymmetrical changes in the mandible ramus height may indicate TMD. Hypotheses were that asymmetry may be an indicator of TMD and that trauma at a young age may lead to growth changes in the height of the mandibular ramus, hence asymmetries.

Design/methodology/approach: An investigated group consisted of 65 patients with TMD, and the control group consisted of 20 patients with no TMD. The images were obtained with a Durr Vista Panoramic system. The differences in the height of the ramus were calculated. Statistical analysis of the results was performed.

Findings: Most patients diagnosed with TMD experienced traumatic events in childhood, while no similar cases were reported in the control group. Significant asymmetry was also found in the TMD group. The gender of the patients did not influence the asymmetries. There was no correlation between the age of the patients and the asymmetry in patients with TMD. Still, the correlation occurred in the control group due to significant asymmetries for the youngest patients.

Research limitations/implications: The small size of the investigated and control group and the fact that patients come from a private clinic in a geographic area with a low population density were limiting factors.

Practical implications: Asymmetries are an indicator of TMD, which may facilitate the early diagnosis of this TMD and the early implementation of treatment using polymeric materials. The knowledge that the development of asymmetry may be related to accidents in childhood or adolescence indicates that such patients should be subjected to preventive observation.



Originality/value: The study offers knowledge useful for designing rehabilitation polymeric materials and devices. Asymmetrical changes in the mandible ramus high may be indicative of TMD. TMD is strongly associated with trauma declared by patients at a young age.

Keywords: Temporomandibular joint, Temporomandibular disorders, Asymmetry, Symptoms, Facial pain, Trauma

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BIOMEDICAL AND DENTAL ENGINEERING AND MATERIALS

1. Introduction

Complications related to the functioning of the temporomandibular joint (TMJ) and the masticatory muscle included by the specialist in the term 'temporomandibular disorders' (TMD) are reported as an important factor that has a strong effect on quality of life [1]. A particularly troublesome symptom for patients is long-lasting and severe pain, the cause of which is often misdiagnosed and not initially associated with TMD. The effects of TMD are treated using engineered devices made of polymer and composite materials. However, patients begin treatment at a relatively late stage, characterised by significant pain, when changes in the anatomical structures are far advanced. Therefore, it is very important to acquire basic knowledge that will allow for early, or even presymptomatic, recognition of the problem and the design of materials and devices to take preventive actions.

Problems of this type are even more difficult to diagnose because they are most likely to have a multifactorial aetiology, ranging from individual factors defined as predisposing through factors that initiate the onset of the disease (e.g., inappropriate joint load) to perpetuating ones resulting from disturbed biomechanics. The occurrence of a noticeable problem to the patient may result from their co-existence [2,3]. Today, temporomandibular disorders are described as a general term related to symptoms such as TMJ pain, headache, mouth clenching, grinding, mouth opening disorders, clicking, masticatory muscle tenderness, and facial pain [4,5]. TMDs are also a fairly common health problem, as significant symptoms occur in approximately 10% of the population [6,7]. Due to the multifactorial background and long-term development of the disease process, diagnosis, especially early diagnosis, is difficult, even though search diagnostic criteria have been developed for temporomandibular disorder (RDC/TMD) [8]. At the same time, it should be noted that the treatment of TMD-related ailments is also difficult due to the multitude of symptoms, and the choice of treatment method is not clear; it often involves a synergistic approach [9], and the effectiveness of the treatment often does not provide the expected results [10]. Therefore, paying attention to all symptoms that may indicate at least a preliminary identification of possible disorders is important, allowing further diagnosis and possibly early treatment.

At the same time, relatively little is known about the root causes of the problems that have arisen. Linking the causes with anatomical changes that cause more problems in patients may create the basis for the use of therapy using modern rehabilitation materials and devices [11,12] in a very early stage of treatment, which will prevent further complications that may ultimately result in the need for TMJ implants [13]. The present study examines whether we can detect asymmetrical changes in the mandible ramus on panoramic X-rays that may indicate TMD. Two hypotheses were formulated. First, face asymmetry caused by high mandible ramus may indicate TMD. The second hypothesis was that, as reported by patients, trauma at a young age can injure the growth centre of the condyle neck and lead to growth changes of the mandibular ramus height, hence asymmetries of the mandible. Those asymmetries may lead to reduced anterior guidance that, combined with trauma, causes pain.

2. Materials and methods

The control group consisted of 20 patients without reported TMD. Age ranged from 25 to 71 years; teens were female, and teens were male. The average age was 53 (for the female and male groups the same). The investigated group was 65, including patients. The ages ranged from 18 to 80 years (average 45 years); 38 were women, and 27 were male. All patients provided their informed consent. All patients came for treatment at a private dental clinic in Bodø, Norway. The clinical examinations were carried out and considered inclusion as follows:

- painful TMD whose diagnosis was based on the previously published criteria for TMD [8,14,15],
- facial pain at least three months before the visit,
- full dental arches,
- orthodontic treatment ended at least one year ago,
- general good health,
- at least 18 years of age,
- fluent in Norwegian or English.

The exclusion criteria were as follows:

- undergoing or completed orthodontic treatment in the last 12 months,
- previous craniofacial surgery and/or noted injuries,
- cognitive impairment,
- psychiatric limitations that may affect the participation in the study assessments.

Consent and questionnaire with respect to symptoms and previous treatment signed. The questionnaire/symptom evaluation was completed by the examining physician according to the principles presented in previous work [10]. Patients are welcome to read the questions in advance in order to obtain the most reliable answers possible. It was determined whether:

- patients experienced pain (continuous or intermittent) and, if so, its location (head, neck, jaw, ear, face or other) was determined,
- if they checked it, what time of the day does the pain appear and in what situations,
- patients have suffered injuries in the jaw or licked area in the past,
- there were factors causing symptoms to worsen or alleviate,
- medications were taken to alleviate symptoms,
- patients hear sounds coming from the TMJ,
- the mandible was blocked, and changes in occlusion were noticed,
- there was hypersensitivity or tooth wear,
- there were ear problems,
- there were problems swallowing,
- you have had any treatment for TMJ.

In addition, palpation was performed to identify painful areas and feel muscle tension. The protocol followed the criteria of the Declaration of Helsinki and the ICH Guideline for Good Clinical Practice.

Images obtained by a dental Durr Vista panoramic system. The Durr radiological protocol was followed. The same operator was responsible for all images. A panoramic X-ray, pixel size 100 μm, 7-sec panoramic scan, 4 mA and 50 kV, magnification factor 1.3. The patient is placed in a face-to-face position. Three positioning light lines precisely mark the Frankfurt horizontal plane, the mid-sagittal plane, and the film plane to position the patient. The approach ensures optimal accuracy on measures. During the evaluation of the high radiographs, the mandibular ramus (left and right) was measured, as shown in Figure 1, by two independent experts, and the mean value was taken as the result. Then, the difference in the height of the ramus was calculated as an absolute value from the difference in the height of the mandibular ramus on the left and right sides.

Fig. 1. Example radiographs with marked high measurements of the mandibular ramus

Statistical analysis of the results was performed using the PQStat 1.8.0 software (PQstat Softwere, Pozna, Poland). Ramus high asymmetry was statistically evaluated using the nonparametric Kruskal-Wallis's test ($\alpha = 0.05$) with the Dunn-Bonferroni post hoc and Mann-Whitney U tests. Pearson's chi-square ($\chi 2$) test for categorical data or Fisher's exact test ($\alpha = 0.05$) was used to analyse the percentage of traumatic patients in groups. Pearson's linear correlation was used to analyse the influence of the patient's age on differences in the ramus heights in groups ($\alpha = 0.05$).

3. Results and discussion

The percentage of patients with TMD who declared a traumatic accident in the past in the temporomandibular joints was 68 %. In contrast, in the control group, no patient declared such problems (Fig. 2). At the same time, in the study group, 32% of the patients do not remember whether they experienced a traumatic event in the future, including in childhood, or declare that they did not experience it. The difference observed between groups was statistically significant ($p<0.0001$)

Comparisons of high differences in the mandibular ramus for groups of TMD patients and in the control group were presented in Figure 3. Statistical analyses confirmed significant differences in the group without division into gender (Fig. 3a), but also for males (Fig. 3b) and women

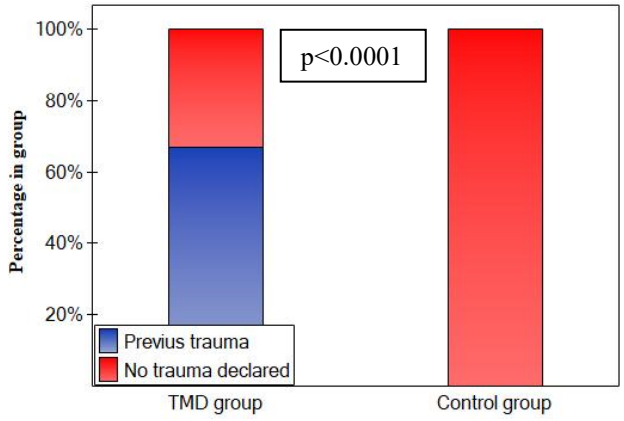

Fig. 2. Percentage of patients who declared a traumatic accident in the TMD group and control group

(Fig. 3c) alone. There were statistically significant differences between the control group and the TMD group after traumatic accidents and the TMD group that had not experienced traumatic accidents, but there were no significant differences ($p<0.05$) between both groups of TMD patients. The median difference in mandibular ramus was high for the control group, which was for the control group 0.2 mm, for the TMD group after trauma 2.8 mm, and the TMD group that had not experienced trauma was 2.5 mm.

There were no statistically significant differences ($p<0.05$) in the mandibular ramus high for any of the investigated groups and the control group according to the sex of the patients (Fig. 4).

There was no statistically significant correlation between age and high ramus differences in both groups of TMD patients (Fig. 5a,b). However, a statistically significant correlation ($p = 0.01$) was observed in the case of the control group (Fig. 5c), that the difference decreased with age. However, it should be noted that the R^2 value of 0.31 is low, so the relationship model explains a relatively small amount of data [16]. The Pearson correlation coefficient value of

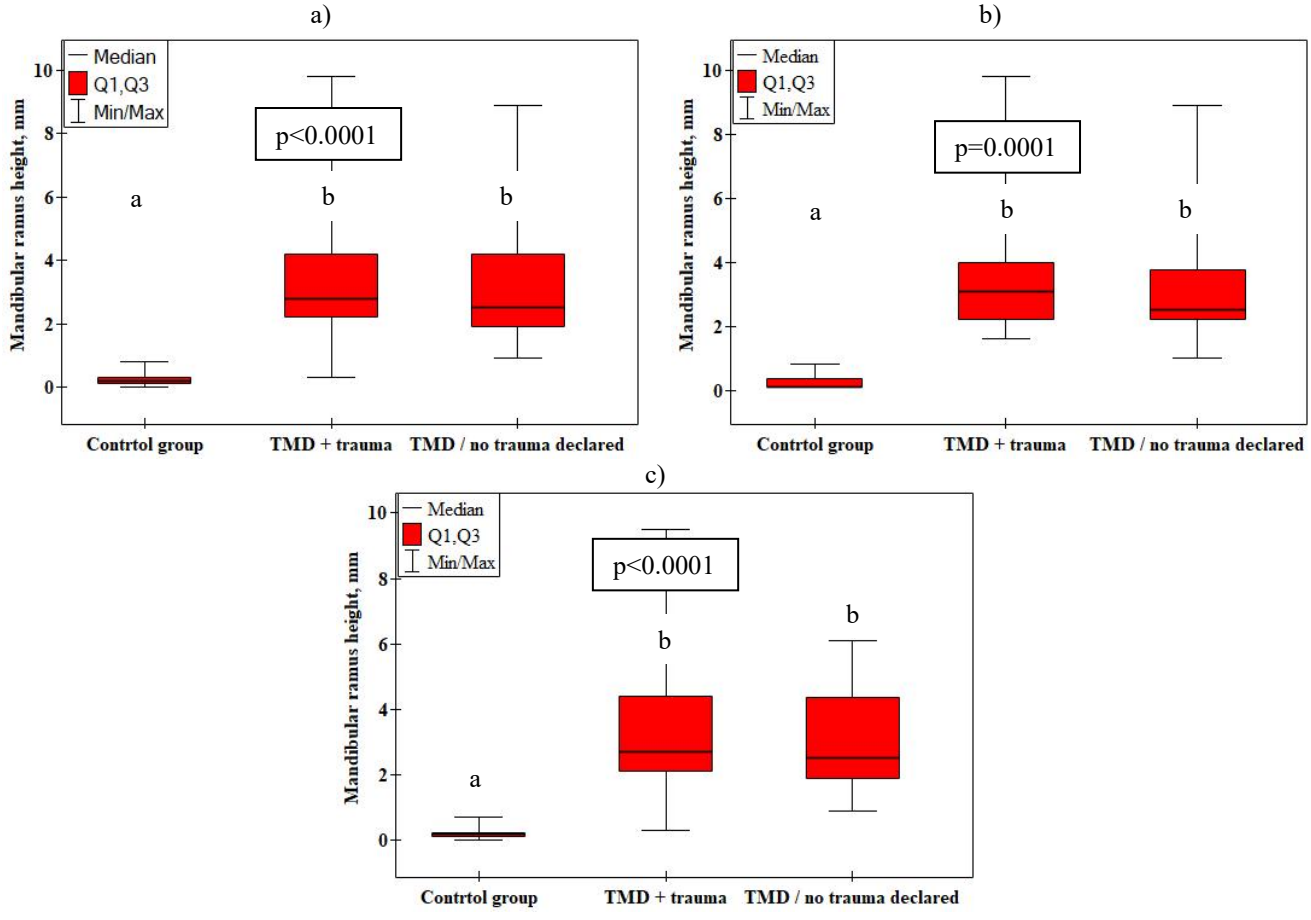

Fig. 3. Comparison of differences in mandibular ramus high for groups of TMD patients and the control group without division into gender (a), in male (b) and female group (c), different letters show statistically significant at the level of $p < 0.05$

-0.557 allows us to conclude that the correlation can be moderate [17-19].

It should be noted that in the control group for two out of three patients under the age of 30 (the two youngest, 26 years old), the highest values (0.7 and 0.8 mm) of differences in the ramus high were observed. Removal of those results from the statistical analysis results in an R-value of -0.245 at p=0.328, so the correlation is no longer statistically significant. Those results, together with the data presented in Figures 3b and c may indicate that the height asymmetry of the mandibular ramus is an important indicator of TMD. The occurrence of the largest differences in the youngest patients in the control group allows us to assume that these people are beginning to experience changes that, in the future, will result in the diagnosis of TMD. The appearance of asymmetry may predict further changes. However, the assumption requires comprehensive future research based on large groups of patients.

The most frequently reported symptoms reported in TMD studies were muscle pain, often accompanied by joint sounds and joint pain, but also head and neck pain in the head. They are symptoms with which patients seeking medical help. However, the ethology of it may be varied, such as predisposing factors (anatomical, psychologic, genetic) [10,20] or external, related to acquired behaviours or experienced sudden accidents [21]. Our work indicates a significant association between asymmetry and the occurrence of subjects with TMD, with the majority of TMD indicating a previous one (in childhood). At the same time, such events were not recorded in the control group. We believe that if trauma affected the disc when the child was growing, it would also affect the condylar neck. Trauma to the condyle neck, which is a growth canter, would possibly affect the growth of mandible ramuses; therefore, the mentioned problem leads to asymmetry. So, trauma in childhood may be the reason for anatomical changes.

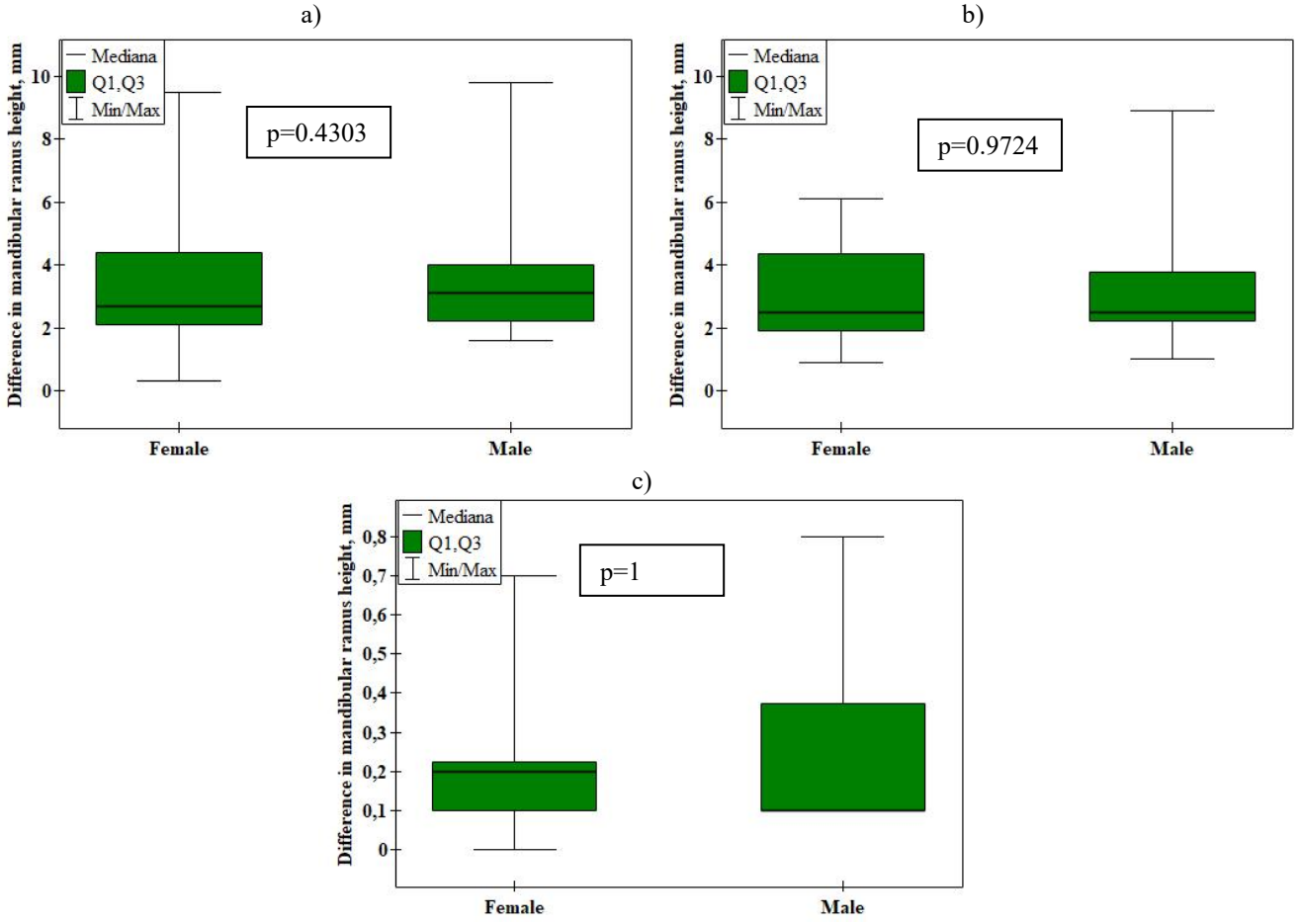

Fig. 4. Comparison of differences in mandibular ramus for males and females in a group of TMD patients who declared (a), didn't declare previous trauma (b) and in the control group (c)

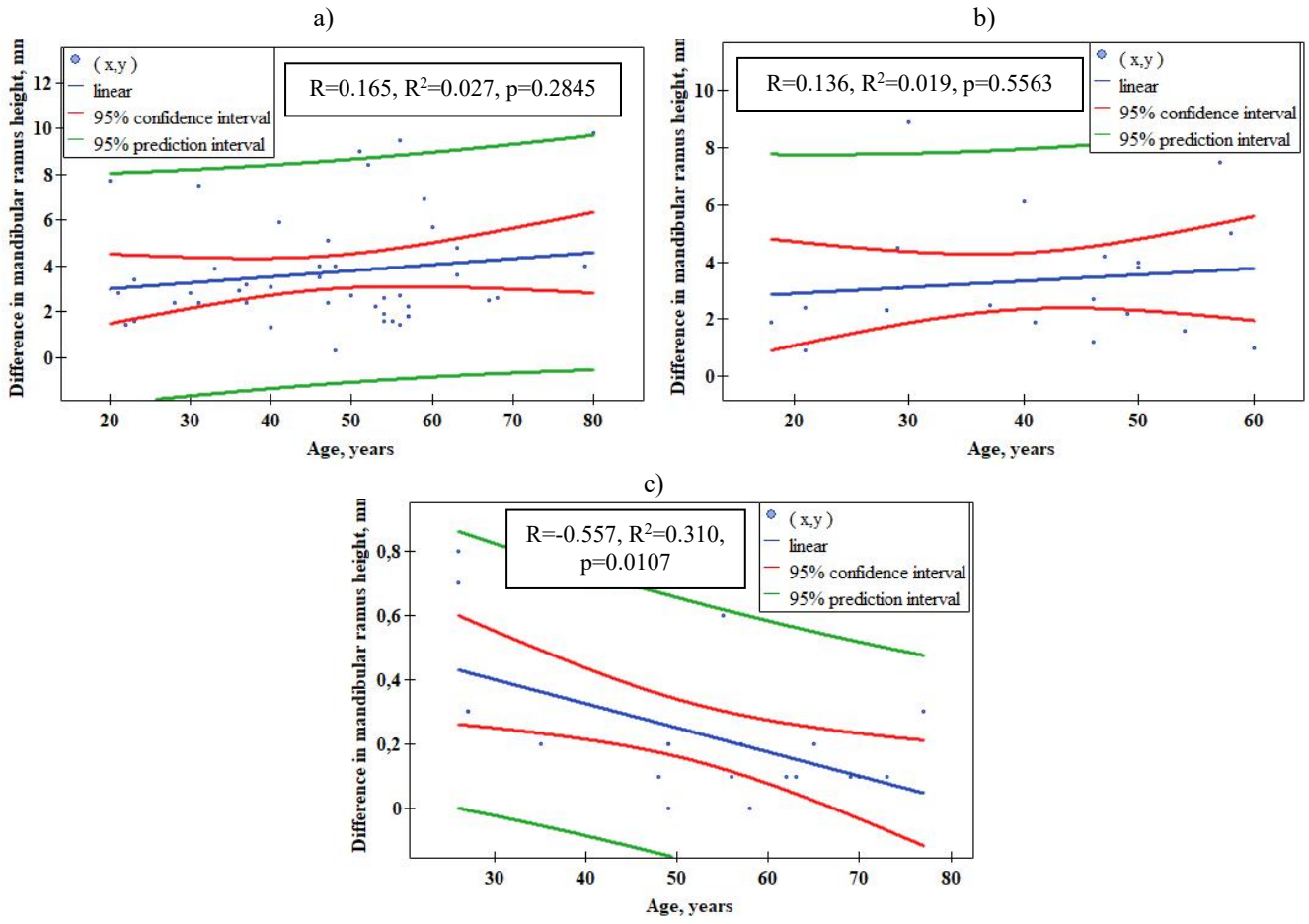

Fig. 5. The correlation between differences in mandibular ramus height and age for groups of TMD patients who declared (a) and didn't declare (b) previous trauma and in control group (c)

The mentioned changes in the disc and height of the ramus due to trauma may alter anterior guidance and the mechanics and function of the jaw joint [22]. It leads to increased muscle tension and more muscle activation due to increased activation of the posterior teeth. Therefore, muscle pain in the stomatognathic system, tension headache, and neck pain. Based on the above considerations, it can be concluded that the trauma experienced may be the important cause of the appearance of anatomical changes, then the pain symptoms, and finally, the diagnosis of TMD. It should be noted here that we considered accidents that happened in childhood, so it should be assumed that 32% of patients who did not declare that they had experienced accidents and may not remember it. The presented considerations also allow us to assume that early detection of asymmetry may indicate the risk of developing TMD in the future and, therefore, is an indication of taking preventive measures.

4. Conclusions

We believe that the study adds additional knowledge to the discussion of TMD, its rehabilitation and prevention through polymeric materials. A current study has shown that asymmetrical changes in the mandible ramus on panoramic X-rays may indicate TMD. Additional TMD was strongly associated with trauma declared by patients at a young age that may injure the centre of the growth of the condyle neck and lead to growth changes in the height of the mandibular ramus, hence asymmetries of the mandible. The small size of the investigated and control groups is a limiting factor. The patients were treated in a private clinic in a geographic area with a low population density, which could also have affected the results. Another limitation is that our work is retrospective, and the sample size was not determined prior to testing.

Data Availability Statement

The data presented in this study are available on request from the first author representing the dental clinic – data is available on request due to restrictions on privacy.

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