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Coronoid-condylar index in assessing of mandibular coronoid hyperplasia. Preliminary results

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ABSTRACT

Purpose: The purpose of this study was to define the coronoid-condylar index (CCI).
Materials and Methods: The material for studies comprised 26 patients. Thirteen patients were treated for bilateral coronoid hyperplasia. The remaining 13 patients were included in the control group. Based on 3D CT measurements, the coronoid-condylar index (CCI) was calculated and assessed statistically.
Results: In patients with coronoid hyperplasia mean CCI was 1.25, while in the control group it was 1.00.
Conclusion: The proposed CCI can be used for the evaluation of anomalies of the mandibular coronoid processes.

Key words: Hyperplasia, mandible, tomography

INTRODUCTION

Bilateral or unilateral coronoid hyperplasia is one of many pathologies limiting physiological mouth opening. These pathologies are rare, and their aetiology has not yet been clearly explained [1]. Most commonly, cases of bilateral coronoid hyperplasia with accompanying characteristic clinical symptoms confirmed by radiological examinations (e.g. CT) usually do not pose diagnostic difficulties [2]. However, scarceness of pathological reactions observed in the clinic between coronoid process of the mandible and the zygoma is either not diagnosed or is erroneously interpreted as dislocation with blocking of an articular disc (Internal Derangement – ID) in temporomandibular joint dysfunction, and then treated with occlusal splint for a long time without success [1].

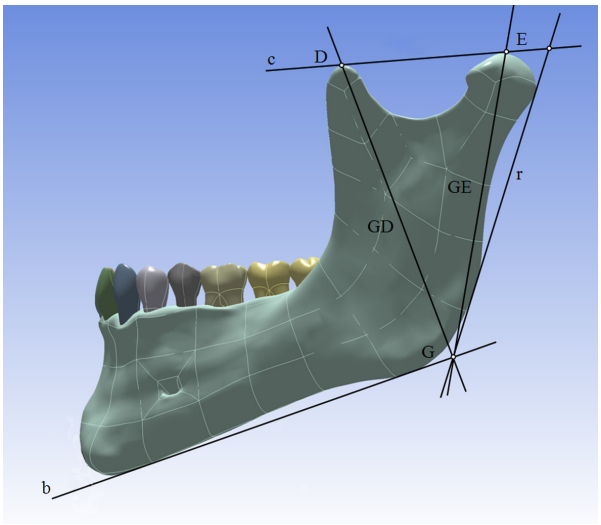
The purpose of this study was to define the coronoid-condylar index (CCI). CCI can indicate disproportion of coronoid and condylar processes.

MATERIAL AND METHODS

The study group consisted of 26 patients from the Department of Cranio-Maxillofacial Surgery, Warsaw. Thirteen of these patients were treated for bilateral coronoid hyperplasia (mean age $\bar{x}$ = 20.5 years; SD = 9.5). The remaining 13 patients (mean age $\bar{x}$ = 23.5 years; SD = 10.1), without disturbances of the occlusion, anomalies of facial skeleton, disease of either temporomandibular joints or masticatory muscles, in whom mouth opening was not affected and was within the range of 43 to 52 mm, were included in the control group. CT of the control group was taken due to head trauma without fracture. The research has been approved by the Bioethics Committee of the Medical University of Warsaw, Poland – AKBE 24/12.

In all 26 patients lateral projection of the mandible in computed tomography imaging with 3D reconstruction was used for the evaluation of geometry of the ramus of mandible. The method of description of mandible geometry enabling measurements is illustrated in *Fig. 1.* The model of

Figure 1. **Lateral projection of a model of the mandible with determined lines and points.**



the mandible shown in *Fig. 1* is a geometric model (Zygote Inc., USA) intended for numerical analyses. The figure shows geometrical construction of the lines, which are base for measurements. In the lateral projections of the mandible, four main lines were drawn: tangent to the apexes of condyle and coronoid process (c), tangent to outlines of a mandible angle and lower margin of the mandible in a mental region (b), tangent to outlines of the mandible angle and posterior part of mandibular head (r). In this way, the following points were determined:

- G – point of intersection of lines b and r,
- E – tangency point of line c and the apex of the head of the condyle,
- D – tangency point of line c and the apex of the coronoid process.

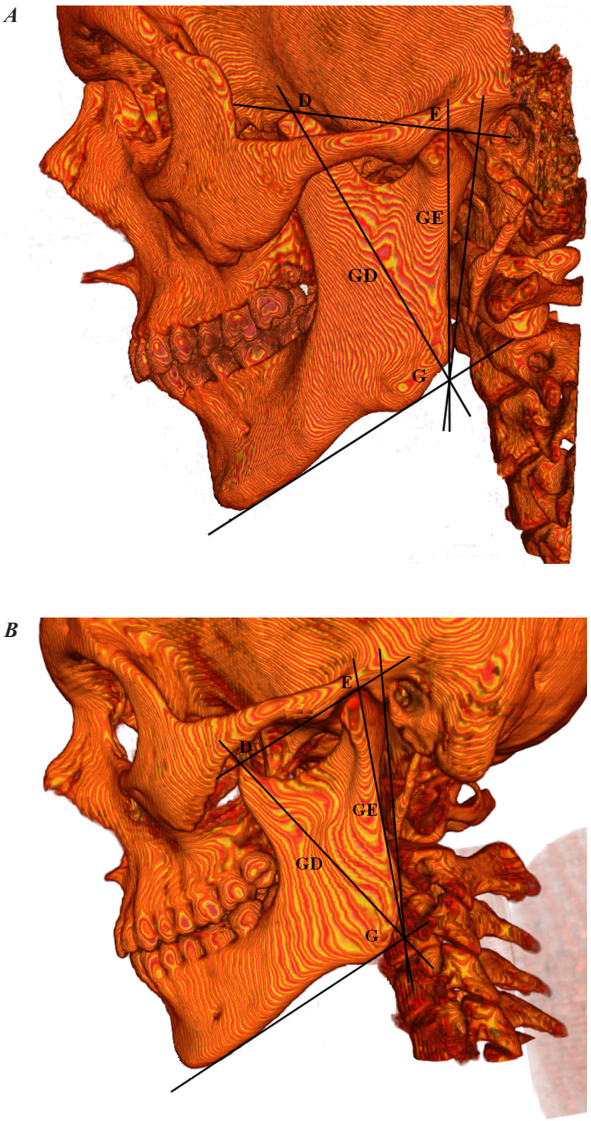
Based on these geometrical points, the length of 2 sections was measured: GE – condylar height, GD – coronoid height. Examples of geometries for the cases with and without coronoid hyperplasia are illustrated in *Fig. 2*. 3D models of the mandible were obtained based on computed tomography with 3D Slicer software. For the evaluation of a degree of coronoid hyperplasia, the proportions of previously determined sections were used. Mathematical formula for calculations of coronoid-condylar index is as follows:

$$CCI = GD:GE$$

For the purpose of this study, measurements of the skull in a lateral projection, obtained by computed tomography examination with 3D reconstruction, have been carried out (*Fig. 3*). In order to avoid errors related to comparison of absolute lengths of individually measured sections, only their proportions were analysed.

The errors in cephalometric measurement are always an important issue [3]. In this case, three sources of errors can be

Figure 2. **Schematic evaluation of geometry of the mandible with the use of its lateral projection in a 3D reconstruction of computed tomography: A) Patient with bilateral coronoid hyperplasia (CCI_L = 1.23); B) Patient without defect of the ramus of mandible (CCI_L = 0.94).**



pointed out. First source is the position of the patient's head, which should assure sagittal view. In this case, the geometry of the skull is obtain by CT, so the position of the head before examination is not so important. The proper, sagittal view is set in 3D software. The second source of error are lines, which are the base for measurements. The lines drawn by each person can differ slightly. The third source of error is the measurement of the GD and GE sections.

In the present study, the measurement of the CCI for one of the patients was performed by 10 medical doctors, according to steps indicated by Houston [3]. The mean value and variance S_d^2 for CCI index for the single patient is 1.047 and 0.005. Standard deviation S_d = 0.022 and the standard error $S_e = (S_d^2/2)^{1/2}$ is 0.015.

RESULTS

The results for both sides of the mandible of 13 patients with bilateral hyperplasia and 13 without coronoid hyperplasia are shown in *Tab. 1* and *Tab. 2*. The comparison of selected proportions and their standard deviations is illustrated in *Fig. 3*. The assumption of variance homogeneity between samples was examined with Levene's test ($p = 0.85$ for the right side and $p = 0.86$ for the left side). The assumption of data matching for normal distribution was examined with Shapiro-Wilk test (the right side with the defect $p = 0.054$; the right side without the defect $p = 0.93$; the left side with the defect $p = 0.44$; the left side without the defect $p = 0.35$). One-way analysis of variance in other cases confirmed the occurrence of significant differences between groups ($p<0.05$).

It has been shown that the proportion GD/GE clearly indicates proportion of the height of the coronoid and the condylar process of the mandible. For the proposed method of measurement in patients without coronoid hyperplasia, this proportion was close to 1.0. If coronoid hyperplasia is present, this proportion is increased and reaches the value of 1.25 (SD=0.07). This value is determined as the coronoid-condylar index (CCI) and is the basis for evaluation of pathology of coronoid processes of the mandible.

According to calculations and statistical evaluation, normal CCI value is up to 1.07. The value above 1.15 is equal to coronoid-condylar derangement (e.g. coronoid hyperplasia). The values of the index between the above limits may indicate pathology of the coronoid process of the mandible.

DISCUSSION

Many specialists who not only treat patients, but also describe the structure of the human body, e.g. anatomists and anthropologists, carry out the measurements of the facial skeleton. Isberg and Eliasson [4] carried out cephalometric analysis of 16 patients with unilateral or bilateral coronoid hyperplasia. They performed lateral cephalographic examinations and found a lack of co-existence of abnormalities in the upper facial skeleton with coronoid hyperplasia. Also, they did not find a statistically significant difference in the length of condyles of the mandible and the control group, which indicated that the pathology is related to the coronoid process itself. Cephalometric examinations of patients are becoming more and more common with the use of computed tomography [5].

Gibbons and Abulhoul [6] reported good results of treatment of patients by means of bilateral intraoral coronoidectomy and mouth-opening appliance. These authors did not describe the measurement of mandibular ramus. Kubota et al. [7] applied the Levandoski panographic analysis of routine panoramic radiographs for improving the diagnosis of hyperplasia of coronoid processes. They described 3 patients with bilateral coronoid hyperplasia and 56 control patients. The ratio of the length of the coronoid process to the condylar process in the Levandoski panographic analysis in the control group was less than 1.07, but in the 3 patients it was higher than 1.14. The authors concluded that when a patient complains of limited mouth opening and the ratio is greater than 1.1, further investigations should be made because of the likelihood of hyperplasia of the coronoid processes of the mandible.

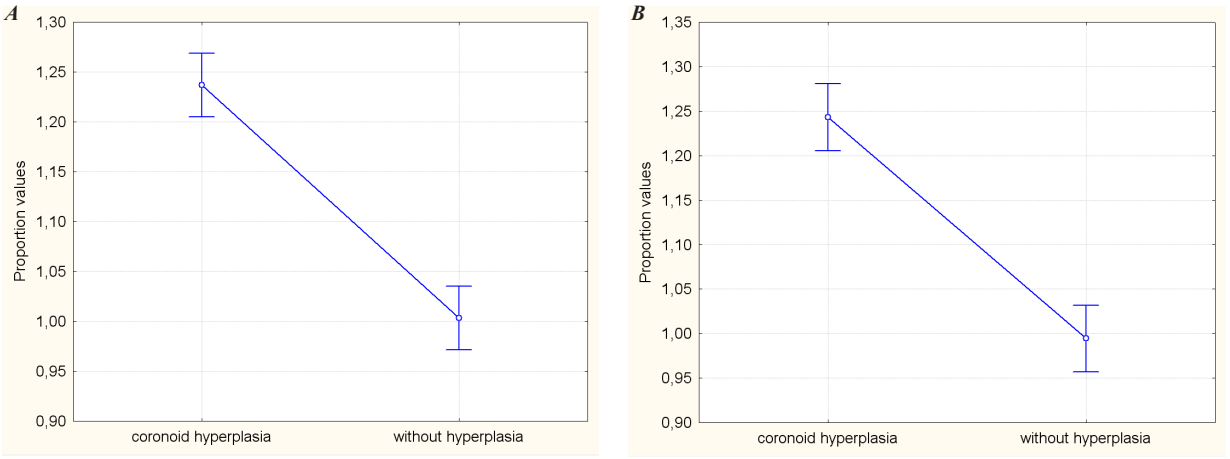
Table 1. **The data of 13 patients with bilateral coronoid hyperplasia.**

Case Nº	Gender	Age (years)	Max range of mouth opening (mm)	DG/EG	
				R	L
1	M	15	16	1.21	1.24
2	M	24	12	1.17	1.24
3	M	17	20	1.22	1.20
4	M	17	13	1.21	1.16
5	M	15	24	1.35	1.38
6	M	16	20	1.33	1.31
7	M	47	15	1.18	1.24
8	M	20	23	1.23	1.29
9	M	18	12	1.21	1.29
10	M	24	15	1.25	1.19
11	M	15	15	1.22	1.18
12	F	33	20	1.28	1.21
13	M	34	19	1.21	1.22
		Mean		1.24	1.24
		Standard deviation		0.055	0.062

Table 2. **The data of 13 patients without mandibular disorder.**

Case Nº	Gender	Age (years)	Max range of mouth opening (mm)	DG/EG	
				R	L
1	F	15	43	1.01	0.97
2	F	19	45	1.04	0.97
3	M	19	47	1.00	1.06
4	M	19	48	0.89	0.86
5	M	23	50	0.98	1.09
6	M	15	47	1.05	1.03
7	M	20	46	1.04	0.98
8	M	35	48	0.97	1.00
9	M	29	45	0.92	0.88
10	M	48	52	1.10	1.09
11	M	17	43	0.96	0.98
12	M	23	51	1.02	1.02
13	F	54	46	1.04	1.00
	Mean			1.00	0.99
	Standard deviation			0.056	0.069

Figure 3. **Comparison of mean values and confidence intervals for the patients with and without coronoid hyperplasia:A) on the right side; B) on the left side.**



Anatomical elements of the mandible may be also measured by means of orthopantomograms as confirmed in the study by Catić et al. [8]. Due to general availability and higher precision of computed tomography examination, including cone beam computed tomography (CBCT), in the present study the measurements were carried out in CT images. The efficacy of CBCT in quantitative evaluation of the maxilla and mandible was determined based on examinations of patients with various abnormalities of the facial skeleton [9]. In 2006, Park et al. [10] proposed a new analysis of morphology of the facial skeleton based on computed tomography 3D examinations. Also, Olszewski et al. [5] confirmed the efficacy of 3D computed tomography for cephalometric analysis. However, for such examination, special software is needed, but the evaluated measurements do not interpret dependence between coronoid process and condyle of the mandible.

Travassol et al. [11] also assessed the ratio of the length of the coronoid process and condyle of the mandible. These authors extended a tangent line to the mandibular notch and then carried out their measurements with this line as the base. Subsequently, they calculated the ratio of the lengths of the coronoid process and condyle and named it coronoid-condylar ratio. Measurements were carried out in 40 healthy individuals. The mean calculated ratio for this group of patients was 0.78. The proposed measurements were performed in only 1 patient with bilateral coronoid hyperplasia. In this patient, the calculated ratio was 2.1 for the left side and 1.87 for the right. It is our opinion that the proposed methodology of measurements is burdened with a significant error due to arbitrary determination of the basic line extending through the mandibular notch.

The use of proportions of sections allowed determining the common standard for individuals manifesting various sizes of craniofacial skeleton. It facilitated not only the analysis of subsequent cases of hyperplasia, but also prevented errors resulting from the comparison of geometrical measurements when measured in different scales and with the use of different measures and units. During the evaluation of the measured distances, it turned out that the ratio of GD/GE sections indicated the anomaly most clearly, i.e. a ratio of the height of coronoid process and condyle of the mandible named in this study as the coronoid-condylar index (CCI). When the CCI exceeds the value of 1.15, the coronoid hyperplasia can be diagnosed.

CONCLUSIONS

The coronoid condylar index proposed in this study enables simple and fast evaluation of disproportion of coronoid and condylar processes of the mandible based on lateral projection of 3D computed tomography in the clinical practice. CCI value above 1.15 indicates coronoid-condylar hyperplasia.

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