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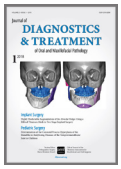

Determination of Coronoid Process Hyperplasia of the Mandible Upon Ankylosing Diseases of the Temporomandibular Joint in Children*

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ABOUT ARTICLE

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ABSTRACT

Purpose.
Ankylosing diseases of the temporomandibular joint (ADTMJ) in children – bone ankylosis and secondary deforming osteoarthrosis (SDOA) lead to an increase in the coronoid process (CP) on average by 1.5 times. The slice computed tomography (SCT) allows fully determining the changes occurring in the bone structures of the joint with its ankylosing diseases. The purpose of the work was to determine the parameters coronoid process, which affects the limitation of mouth opening, and indications for its resection in the ADTMJ, based on the treatment of SCT data.
Material and Methods.
The subject of the study were 33 SCT in children aged 6 to 14 years with ADTMJ and without lesions of TMJ. Anthropometric measurements of CP in children of the three groups were performed according to the proposed modified scheme of Levandoski panographic analysis.
Conclusion.
The proposed scheme of anthropometric measurements of SCT allows us to mathematically substantiate the stage of hyperplasia coronoid process in children and to determine the necessity of its surgical correction.

Introduction

Ankylosing diseases of the temporomandibular joint (ADTMJ) in children – bone ankylosis and secondary deforming osteoarthrosis (SDOA), make up from 53% to 86% among all joint diseases and 8-11% of surgical stomatological diseases in children [1, 3-5, 7].

The bone deformity, which constantly accompanies ADTMJ, is hyperplasia of the coronoid process (CP). According to various authors in ankylosing diseases, it increases by 1.5 times [6, 5, 10, 12, 13].

Timely and reliable diagnosis of bone ankylosis and SDOA TMJ is the basis for choosing the optimal individual therapeutic tactics [2, 3, 5, 6, 11, 15]. CT is used today in all diagnostic protocols to find out changes in the bone joint elements at ADTMJ [3, 6, 8, 9, 13-15]. The value of CT is that 3D image allows to evaluate the nature and extent of pathological changes not only in the joint, but also the processes of the lower jaw, the facial bones and their interrelations. To determine the degree of explosives used methodology by Levandoski [10-12, 14]. The latter involves calculating the height, the width of the base of the CP, the angle between the condylar process and coronoid process. The Levandoski method detects the presence of hyperplasia of CP, but does not answer the question of which exactly changed parameters require resection of the CP [10, 15].

The purpose of the work: to determine the parameters of hyperplasia of CP of mandible, which affect the limitation of mouth opening, and indications for its resection in the ADTMJ on the basis of data processing slice computed tomography (SCT).

Material and Methods

The subject of the study were 33 SCT children aged 6 to 14 years. Depending on the damage of TMJ is divided into three groups: I group – 8 children with SDOA TMJ, II group – 6 patients with bone ankyloses TMJ, III – control group of 19 children without TMJ lesions.

Anthropometric measurements of CP in children of the three groups were performed according to the

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proposed modified scheme of Levandoski panographic analysis. S is the width of the basal CP, measured as the anterior-posterior dimension from the lower point of the incisure of the mandibular branch, lowering the perpendicular to the leading edge of the basal coronoid process (Fig 1). The height (h) of the CP was determined as the perpendicular that was lowered from the top of the coronoid process to the line S. The angle α – is formed between the CP and the condylar process had sides passing between the highest points of the processes of the mandible and the lowest point of the incisure of mandible. Additionally, measure the distance L, which was determined between the top of the CP and the inner surface of the zygoma, as an indicator of the degree of mobility of the mandible. For the data processing of SCT, the Horos program was used.

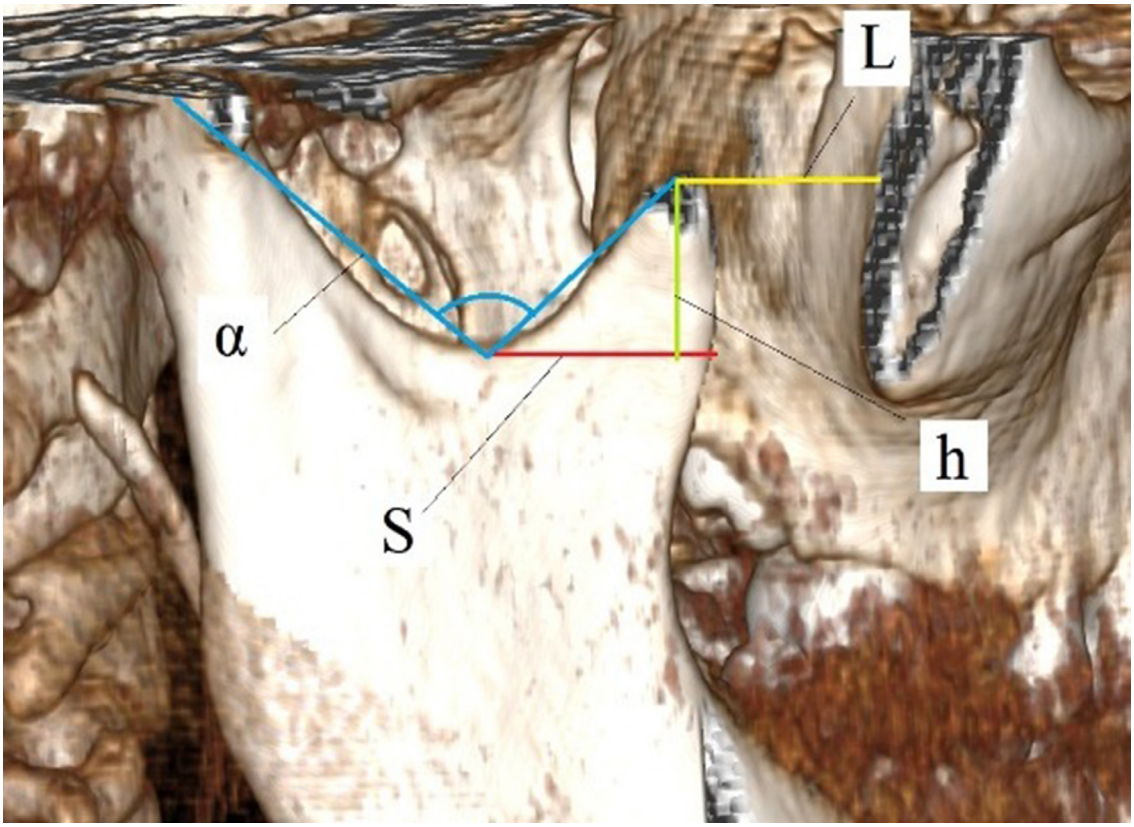

FIGURE 1. 3D reconstructed CT image. Scheme of anthropometric measurements of explosives according to the proposed modification. The height (h) of the CP was determined as the perpendicular that was lowered from the top of the coronoid process to the *red line S*. The angle α – formed between *blue lines* (CP and the condylar process) had sides passing between the highest points of the processes of the mandible and the lowest point of the incisure of mandible. Additionally, measure the distance L (*yellow line*), which was determined between the top of the CP and the inner surface of the zygoma, as an indicator of the degree of mobility of the mandible.

Electromyography (EMG) of temporal muscle was performed on an electromyograph of the type EEG-16 S Medicor®, Buclapest, Hungary. The difference in the muscle biopotentials was recorded by the biopolar method from the healthy and affected side, and the bioelectric activity (BEA) of the temporal muscle in the phase of relative rest (X1) and in the active phase (X2) was determined. The measurement range was the standard deviation.

Results

The technique of paired analysis of Levandoski by us was modified by introducing a new index of mobility of the jaw L. This indicator is a summary reflection of the changes that occur with CP. Increasing the height and width of the bases of the CP helps to change its position, namely the top and the back. This, in turn, leads to a decrease in the angle between the CP and the condylar proces, which affects the spatial displacement of the blood vessels in the movements of the lower jaw. In hyperplasia CP, this distance significantly decreases and when the jaw moves in the sagittal plane, it is blocked. Indicator L is fundamentally important for determining the mobility of the mandible (Fig 2). When opening the mouth there is a reduction of chewing muscles, the head of the condylar process of the mandible performs sliding movements, moves to the articular hump. Together with it, it moves in the sagittal direction and the CP, the apex of which approaches the inner surface of the chick bone and the mouth opens. With reduced distances between the top of the CP and the zygoma, there is a blockage of opening the mouth due to the contact of these bone anatomical formations, which is normally absent.

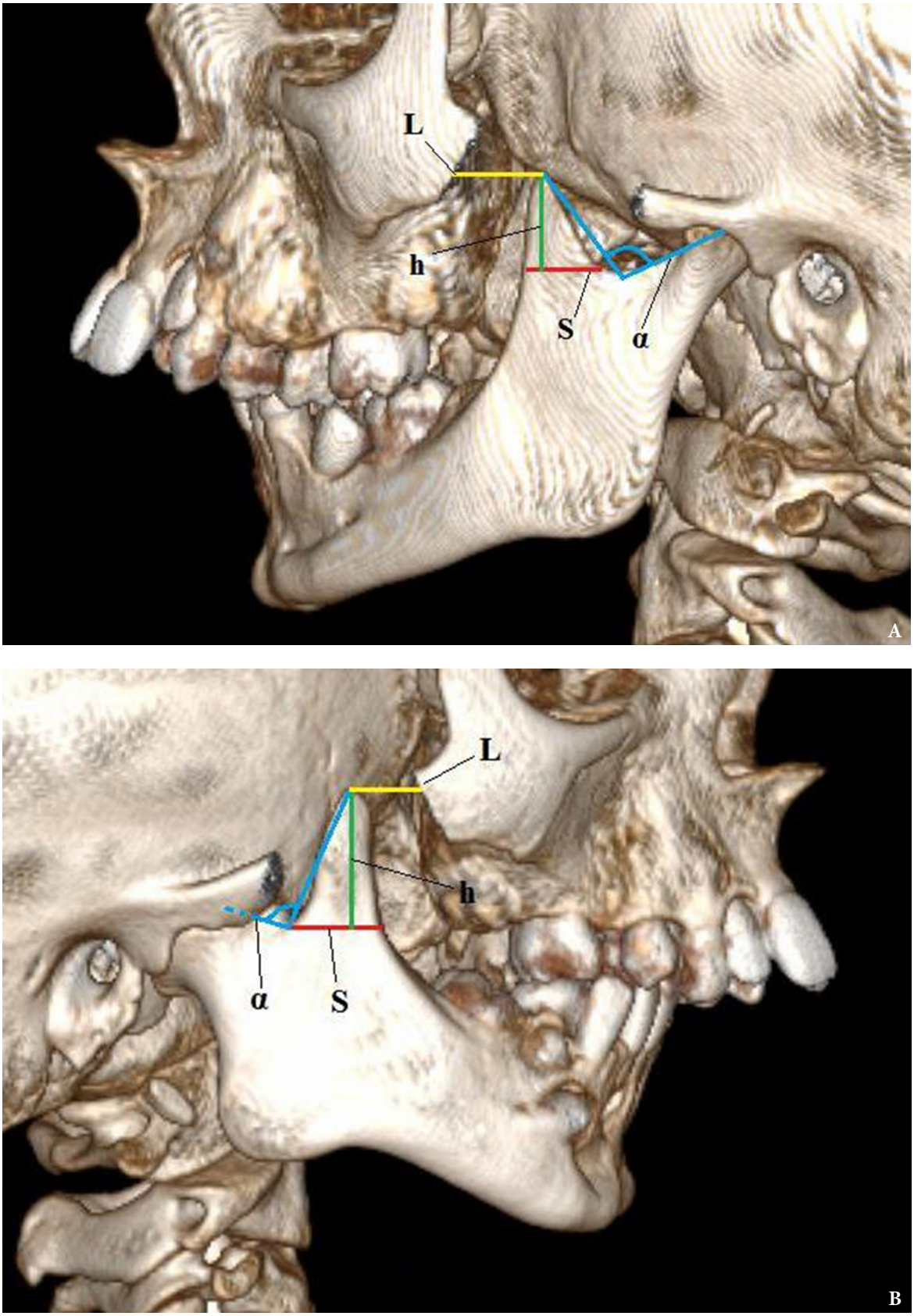

FIGURE 2. 3D reconstructed CT images (**A**, **B**). Scheme of calculations of anthropometric indices of the patient's CP and patient with unilateral SDOA: **A** – healthy; **B** – the affected side. The height (h) of the CP was determined as the perpendicular that was lowered from the top of the coronoid process to the *red line S*. The angle α – formed between *blue lines* (CP and the condylar process) had sides passing between the highest points of the processes of the mandible and the lowest point of the incisure of mandible. Additionally, measure the distance L (*yellow line*), which was determined between the top of the CP and the inner surface of the zygoma, as an indicator of the degree of mobility of the mandible.

The mean values of the CP jaw values for children in the norm of the age group from 7 to 12 years, which were determined according to the method proposed by us, were: S = 4.9 ± 0.87 mm; h = 9.6 ± 1.41 mm; α = 82.0° ± 2.11°; L = 7.25 ± 0.83 mm (Table 1). In this case, the mobility of the mandible was not disturbed and the opening of the mouth was free.

TABLE 1. Results of anthropometric measurements of CP in the control group children.

#	Age	Sex (m/f)	Affected side (R/L/R+L)*	Size of CP of Mandible (III Control Group – Norm)							
				L				R			
				S (mm)	h (mm)	α (°)	L (mm)	S (mm)	h (mm)	α (°)	L (mm)
1.	7	f	-	4.3	9.1	79	6.7	4	9	83	6.5
2.	7	f	-	4.9	8.5	81	6.6	4.8	8	81	6.7
3.	8	f	-	4.5	9.2	80	7.2	4.5	9.2	80	7.1
4.	8	m	-	4.5	9.6	85	7.3	4.6	9.4	80	7.6
5.	8	m	-	5	10.2	90	7.4	4.4	9.5	84	7.1
6.	9	f	-	5.2	9.8	84	7.6	5.2	10	79	7.6
7.	9	f	-	5.4	10.3	85	8.0	6	10.9	81	7.4
8.	9	m	-	4.9	8.5	79	7.1	4.9	9.5	85	7.2
9.	10	f	-	6	11.4	80	8.4	5.9	11.3	80	8.1
10.	10	m	-	6	10.9	78	7.6	5.9	10.9	80	8.3
11.	10	m	-	5.4	12.5	77	8.1	5.6	13.5	78	8.1
12.	11	f	-	6.2	12.4	79	8.1	6.3	12.3	80	8.5
13.	11	f	-	5.9	11.2	78	8.3	6	11	79	8.4
14.	11	m	-	6.6	11.4	83	9.3	6	12	77	9.0
15.	12	f	-	6.4	12.5	81	9.1	7	12.8	78	9.1
16.	12	f	-	7	13.8	83	8.9	7.2	13	77	8.9
17.	12	m	-	6.9	12.3	81	9.7	7.2	11.8	78	9.8
18.	13	m	-	7.6	13.6	80	9.9	8	13.1	77	10.0
19.	13	f	-	7.3	13.2	84	9.1	7.4	13.2	81	9.2
			M±m	5.8 ±0.84	11.1±1.43	81.4±2.53	8.1±0.81	5.8±0.92	11.1±1.40	79.9±1.70	8.1±0.84

** R — affected right side; L — affected left side; R + L — bilateral joint lesion*

We have not identified the gender differences in the anthropometric indicators of CP in healthy children. The largest increase in the values of the indicators was observed in children from 10 to 13 years: S = 1.6 ± 0.87 mm; h = 3.7 ± 1.41 mm; α = no significant changes; L = 1.3 ± 0.83 mm. Between the right and left sides there was a fluctuation in the values of anthropometric indicators, which can be explained by the habit of chewing more on one side, but they did not have any significant differences.

The results of measurements of the width of the S CP at the ADTMJ indicate an increase in its basis (Table 2).

For unilateral SDOA S of CP is 5.9 ± 1.03 mm, which is 1.0 mm more than normal (Fig 3). For bilateral SDOA, the width of the base of the CP reaches 6.8 ± 1.15 mm, increasing the difference by 1.9 mm. This indicator for ankylosis also had a steady tendency to increase: at unilateral 6.8 ± 0.89 mm / gain was + 2.5 mm, bilateral 6.4 ± 0.85 mm / gain + 2.0 mm in comparison with norm (Fig 3). The increase in the value of S for ankylosis and bilateral SDOA was the same and amounted to an average of 2.1 ± 0.85 mm. This can be explained by the fact that CP suffers the greatest burden precisely at these joint lesions due to the strain of chewing muscles and the imbalance of movements in the TMJ. Comparison of the healthy side index with one-sided ADTMJ with the norm – gave it an increase of only 0.3 mm with SDOA and 2.9 mm – with ankylosis.

The height h CP in children with one-sided SDOA was 14.8 ± 3.45 mm, which was 5.2 mm (N = 9.6 ± 1.41 mm) more than in control group children, and when compared with the unaffected side (10.7 ± 3.75 mm) more than 4.1 mm (Fig 4).

Indicator h CP for bilateral SDOA TMJ in children reached the values 17.8 ± 3.65 mm. The difference in the scores between one- (h^1) and two-way lesions (h^2) of this group was 3 mm (h^1 and h^2). In children with unilateral ankylosis, the value of the height of the explosives was 13.3 ± 1.88 mm, and bilateral – 15.1 ± 1.34 mm. The difference h^1 and h^2 was about 2.0 mm. This can be explained by the

TABLE 2. Results of anthropometric measurements of CP in children with SDOA and ancylosis TMJ.

#	Age	Sex (m/f)	Affected Side (R/L/R+L)*	Size of CP of Mandible (I Group – Patients With SDOA)							
				L				R			
				S (mm)	h (mm)	α (°)	L (mm)	S (mm)	h (mm)	α (°)	L (mm)
1.	7	f	L	5.5	14.5	67	4.2	4.0	9.6	69	6.1
2.	8	m	R+L	7.0	21.5	66	41	6.8	22.1	69	4.2
3.	9	m	L	6.6	17.5	58	4.0	5.7	10.3	65	6.9
4.	9	f	L	5.3	17.0	59	4.5	6.0	12.3	69	6.0
5.	10	m	R+L	8.2	15.3	69	4.5	8.2	15.8	65	4.0
6.	11	f	R+L	6.7	24.5	65	3.7	8.4	25.1	66	3.8
			M±m	6.4±1.03	17.6±3.60	64.0±3.67	4.2±0.23	6.5±1.28	16.7±3.75	67.2±1.83	5.2±1.17
#	Age	Sex (m/f)	Affected Side (R/L/R+L)*	Size of CP of Mandible (II Group – Patients With Ankylosis)							
				L				R			
				S (mm)	h (mm)	α (°)	L (mm)	S (mm)	h (mm)	α (°)	L (mm)
1.	7	f	R+L	4.9	15.6	65	3.2	5	14.3	65	3.7
2.	9	f	R	6.6	9.5	74	7.2	6.4	13.1	65	4.1
3.	9	m	R	5.7	11.2	69	6.7	5.8	11.3	70	4.6
4.	10	f	R+L	6.4	15.6	69	3.9	6.5	14.6	69	4.1
5.	10	f	R+L	7.5	17.1	61	4.6	7.7	16.3	66	4.2
6.	12	f	R	7.5	11.6	72	7.4	7.4	13.9	68	4.3
7.	13	m	R	7.9	12.2	62	8.3	7.5	13.0	69	4.1
8.	14	m	L	7.1	14.3	66	4.2	8.2	13.7	66	7.6
			M±m	6.7±0.80	12.9±2.12	67.3±3.75	5.7±1.71	6.8±0.89	13.5±1.88	67.3±1.75	4.6±0.76

** R — affected right side; L — affected left side; R + L — bilateral joint lesion*

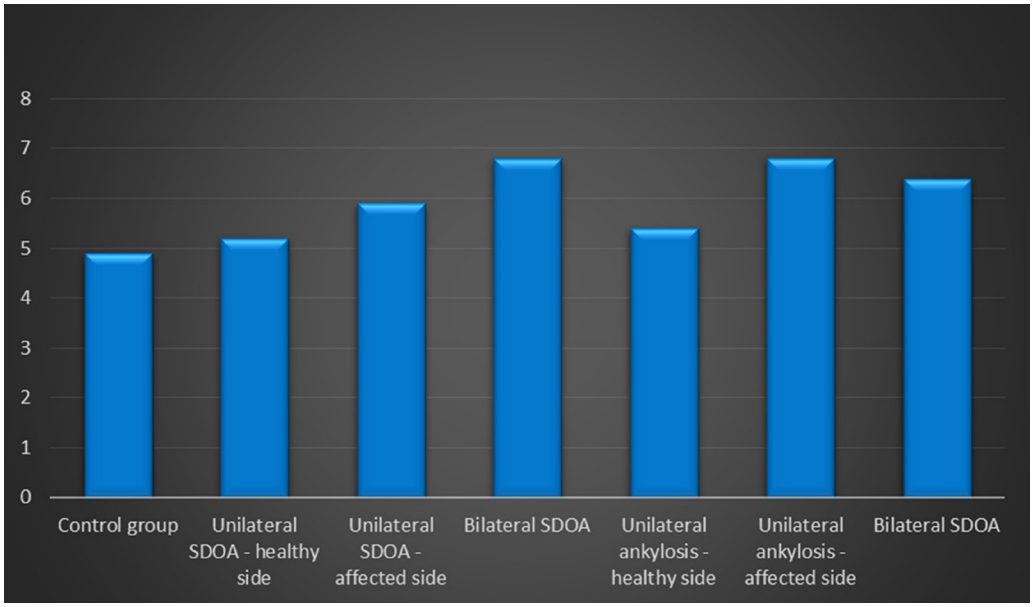

FIGURE 3. Results of measurements of S CP of mandible in patients I, II, III groups.

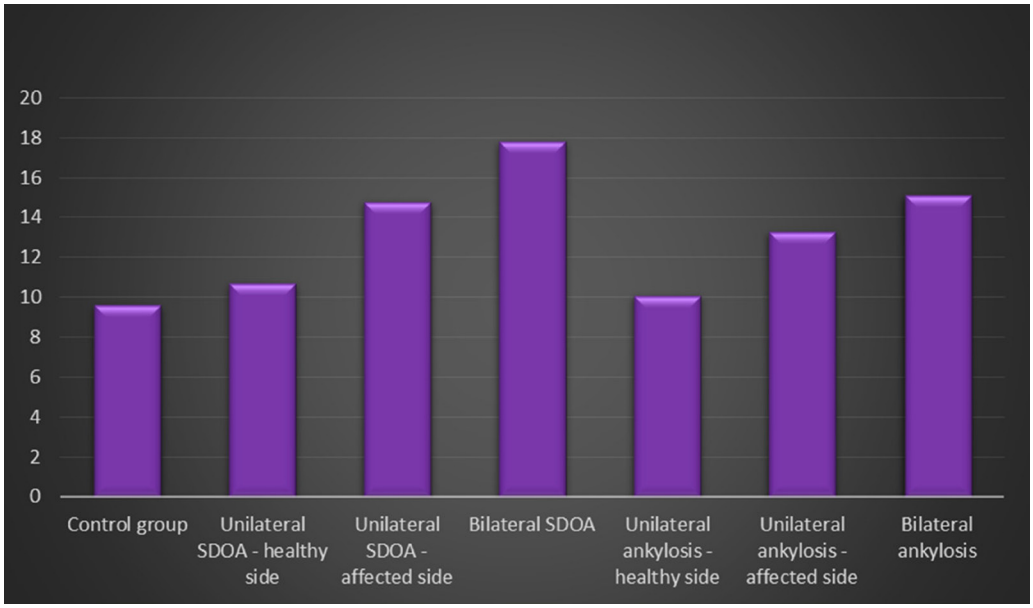

FIGURE 4. Results of measurements of S CP of mandible in patients I, II, III groups.

fact that with SDOA TMJ children retain small movements in the joint of the jaw and, accordingly, the load supports the trophism of the temporal muscle, which indirectly affects h CP. The difference was only when comparing the healthy side and affected by unilateral ankyloses and was 3.2 mm. Consequently, in all clinical cases, both groups had an increase in h, with the maximum being for bilateral SDOA and all types of ankylosis. The difference between the values h^1 and h^2 was greater when SDOA was 3 mm or less with 1.8 mm ankylosis. The comparative characteristic of the norm of height h with the healthy side with one-sided lesions gave it an average increase of 5.65 ± 2.34 mm, (SDOA – 6.55 mm / ankylosis – 4.62 mm). This indicator is a component of hyperplasia of the CP with ankylosis and SDOA TMJ and gives an idea of the mechanism of violation of opening the mouth in the patient. It should be noted that h is proportional to the maximum for bilateral joint damage. Such an increase in h CP is due to the vertical inclination of m.temporalis and the constant increased tonus of chewing muscles. This is evidenced by the data of EMG, namely the reduction of the temporal muscle, which, in the absence of movements in the joint, doubles the voltage of 2.041 μV (N = 0.942 μV).

The angle α for SDOA and ankylosis was 64.0° ± 2.75° and 67.8° ± 2.75°, respectively, which was lower than in children without lung lesions (82° ± 2.11°) (Fig 5). It should be noted that in one-sided SDOA he < at 6° compared with the healthy side, and with ankylosis < only 2°. On average, the angle α decreased by 12 degrees relative to the norm.

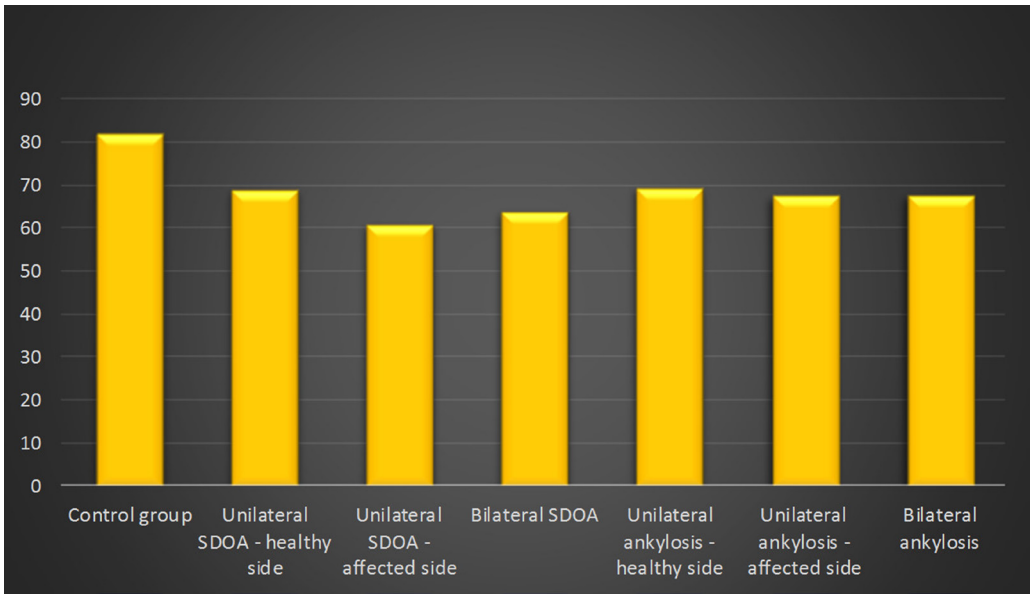

FIGURE 5. The results of measurements of the α CP of mandible score of patients in groups I, II, III.

Such changes of the angle at ADTMJ associated with the difficulty of the movements of the jaw and, consequently, the constant tension of the temporal muscle, whose myotatic vector, directed vertically upwards. The imbalance in the loading of chewing muscles in SDOA leads to an asymmetric hypertrophy of the temporal muscle. The obtained EMG data showed an increase in its voltage alone (X1) on the affected / healthy side – 2.041μV / 0.942μV, with compression (X2) – 81.61 / 107.52μV, respectively. With ankylosis, these rates increase. Voltage of temporal muscle at rest on the affected side was equal to 2.961μV, and at compression of 119.01 μV, indicating excessive bioelectric activity of it. This in turn leads to increased trophics in the affected area of the bone, which also contributes to hypertrophy of the CP of mandible. The expressed hypertrophy of the latter with ADTMJ is due also to the fact that the growth of the mandible changes the growth modulus from the condylar process of the jaw to its related vector – CP of mandible [3, 5].

The indicator L proposed by us indirectly indicates a violation of the mobility of the jaw. Normally, the values of L were within the range of 7.25 ± 0.83mm. In one-sided and bilateral SDOA TMJ, the average figures were 4.2 ± 0.23 mm and 4.1 ± 0.70 mm respectively; at ankylosis – 4.3 ± 0.76 mm and 3.95 ± 1.24 mm (Fig 6).

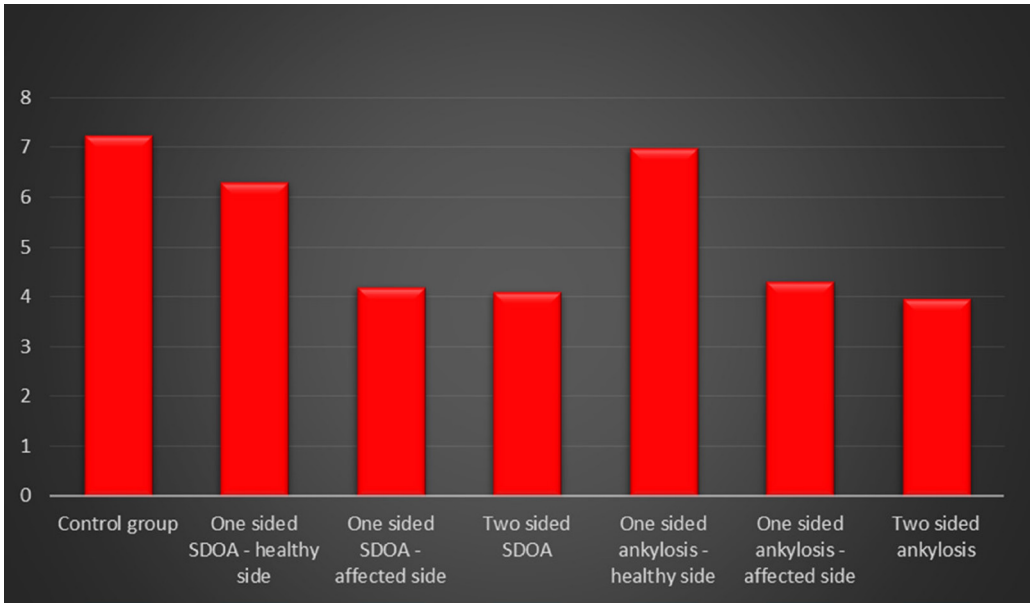

FIGURE 6. Results of measurements of the L index of CP of mandible in patients I, II, and III groups.

That is, in children of the 1st and 2nd groups he was reduced by an average of 3.1 mm. Comparing the indicator L with one-sided lesions of the TMJ with the healthy side, it was established that at: SDOA it was 4.2 ± 0.23 mm, which is 2.1 ± 1.01 mm less, compared to the healthy side, and 4.3 ± 0.76 mm – with ankylosis, which is 3.2 ± 1.17 mm smaller, respectively. This indicator is vividly illustrated by the fact that even at a reduced angle between the processes, if the indicator L is ≤7.0 ± 0.33 mm, then the free opening of the mouth in patients with ADTMJ is difficult. Normally, with bilateral contraction of the masticatory muscles, the lower jaw moves forward, with the distance between the vertex of the CP and the inner surface of the chick bone reduced to 3-4 mm, but the CP, while not touching the latter. At ADTMJ, this distance decreases by an average of 3 mm and when moving the CP to the front, he rests in the spine, which blocks the further opening of the mouth. Changes in height, width and angle of the CP at ADTMJ are a summary indicator based on our proposed indicator L, which reflects the biomechanics of the movements of the mandible at the opening of the mouth.

The determined changes in CP indexes on the unaffected side of the joint with SDOA and ankylosis can be explained by the fact that TMJ is a pair of joints and the occurrence of changes in one of them leads to "deviations" in the second one. It is important that, in the case of one-sided SDOA / ankylosis, the determination of changes in blood pressure on the unaffected side with known anthropometric indices makes it possible at the planning stage to determine the need for resection of the blood vessels not only on the affected side, but also on the healthy one.

The h / S ratio indicates an increase in CP in children with TMJ lesions, especially with bilateral SDOA and unilateral ankyloses up to 2.75 mm, which is 1.5 mm larger than N = 1.95 ± 0.62 mm. The h / L ratio, as the index of mobility of the jaw was higher in all children compared to control, namely: with bilateral lesions TMJ – 4.26 mm, with one-sided – 3.52 mm. This is almost 4 times more than normal in the case of bilateral

SDOA and ankylosis and, almost 3 times – at one-sided ADTMJ. Indicators of these relations, in our opinion, are extremely important, because they determine the degree of mobility of the jaw in its movements. And if they increase several times – h / L 4 times with ankylosis and 2.7 times with SDOA, then multiples of this changes the mobility index L, and thus the volume of movements of the mandible decreases towards the limitation of the opening of the mouth.

Thus, all three indicators of CP are altered with ADTMJ, with the largest changes developing in children of the II group with ankylosis TMJ and smaller in children of the 1st group with SDOA. With these diseases of the joint, the base of the joint increases with an average of 2.1 mm. The most significant changes occur at the height of the CP, where h varies from 13.3 ± 1.88 mm to 17.8 ± 3.65 mm, depending on the type of joint damage that was 5.9 mm higher than normal. Changes in h and S influence the angle α, which decreased with SDOA by 18°, And with bone ankylosis by 15° compared with N = 82° ± 2.11°. Probably the children are compensatory reorganization of the spatial orientation of the CP to maintain the mobility of the jaw. According to the results of SCT studies, it was determined that with an increase of h more than 14 mm and a S ≥6,0 mm and a ratio of h / S = 2.2 mm, h / L = 3.8 mm and L ≤ 4.5 mm, a blockage of the lower jaw occurs during sagittal and its vertical movements, which interferes with the free opening of the mouth in patients with ADTMJ. Thus, the combination of subjective indicators made it possible to determine the hyperplasia of CP of mandible and indications for its resection in children from ADTMJ at the stage of diagnosis according to SCT and accordingly plan the volume of surgical interventions.

Conclusions

1. The proposed scheme of anthropometric measurements of SCT allows us to mathematically substantiate the stage of hyperplasia of CP of mandible in children and determine the need for its surgical correction.
2. Our proposed indicator L is an indicator of the mobility of the mandible and reflects the changes that occur with the CP in the ADTMJ. Its values are taken into account in determining the indications for osteotomy CP.
3. It was found that the most significant changes were observed in bilateral SDOA and ankylosis: S = +2.1 mm; h = + 6.8 mm; α = -18°; L = -3.0 mm.
4. Indications for the resection of CP are an increase in h of more than 14 mm, S is 7.0 mm, α≤69°, and the h / L ratios = 4.4 mm and h / S = 2.1 mm and a decrease of L to 4.5 mm.

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Conflict of Interests

The authors declare that they have no conflict of interest.

Role of Author

The authors are equaly contributed to that article.

Ethical Approval

Approval was obtained from the Medical Ethics Committee of the Bogomolets National Medical University, Kyiv, Ukraine.

Patient Consent

Not required.

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