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Cephalometric Indicators of the Vertical Dimension of Occlusion

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A B S T R A C T

The aim of this investigation was to establish precise indicators of the vertical dimension of occlusion (VDO) which could be used as objective parameters in prosthodontic treatment providing exact control of the reconstructed vertical dimension of occlusion, early detection of errors and correction of the vertical dimension of occlusion during complete denture manufacturing. A total of 60 lateral cephalometric radiographs of subjects with natural dentition and class I skeletal jaw relationship, of Serbian nationality from the region of Vojvodina, were included in the investigation. Thirty subjects were males, and thirty females, their age range was 20 to 29 years. Cephalometric analysis was performed by using »Dr. Ceph« computer software (FYI Technologies, GA, USA). By evaluation of the craniofacial complex in subjects with natural dentition, horizontal dentofacial developmental growth was established in the examined sample and it was based on the relationship between the posterior and anterior total facial height (S–Go:N–Me, ♀ $\overline{X}$=68.96%, ♂$\overline{X}$=72.8%) and statistically significant differences were found between the sexes in almost all linear dimensions and in the relation between the posterior and the anterior total facial height. Highly significant differences ($p<0.001$) between the sexes were found in regard to anterior total facial height (N–Me, ♂$\overline{X}$=120.75mm, ♀ $\overline{X}$=112.72mm) and the anterior lower facial height (ANS–Me, ♂$\overline{X}$=67.87mm, ♀ $\overline{X}$=61.50mm) ($p<0.05$). The proportions of the upper and lower anterior facial heights (N–ANS:ANS–Me, ♂$\overline{X}$=79.36%, ♀ $\overline{X}$=80.63%) were within normal values in both sexes. Facial harmony existed both in men and women. Cephalometric study of the subjects with complete natural dentition included in this study provided important and specific parameters for optimal reconstruction of vertical dimension of occlusion in the treatment of edentulous patients.

Key words: *cephalometry, facial bones, vertical dimension of occlusion, edentulous*

Introduction

Changes of the hard and soft tissues of the face and jaw complex following tooth loss and loss of support provided by natural occlusion lead to drastic changes in the vertical dimension of the lower face. Correct determination of vertical dimension of occlusion (VDO) is of utmost importance for the functional and physiognomic rehabilitation of such patients. Therefore it is necessary to identify objective parameters in order to achieve directions for optimal reconstruction of the VDO in prosthodontic treatment of edentulous patients. Current knowledge on the morphological and functional aspects of maxillo-facial complex, knowledge on genetic complexity of certain morphological structures, knowledge on inseparable association between morphology and function, and on individual course of neuromuscular processes within the system, have necessitated a need to reconstruct the previous natural VDO as precisely as possible[1–6]. The success of future dental prosthesis is directly associated with the success of reconstruction of the original occlusion. The reconstruction of the original VDO in complete denture wearers provides safe and fast rehabilitation of the impaired function of the stomatognathic system, fast adaptation to prosthesis, and at the same time it is the best guarantee of patients' satisfaction[7–11]. Determination of the original and therefore functionally optimal VDO with removable dental prostheses significantly decreases the

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possibility of »dysadaptation« of the stomatognathic system to new circumstances inflicted by the prosthesis, which usually manifests with various diseases of the temporomandibular joints, muscle dysfunction and atrophy of the oral tissue[2,3].

Determination of individual, morphological indices of VDO, using cephalometric analysis, represents one of the ways to identify better solutions in planning artificial occlusion complex. It specifically allows determination of the VDO in regard to those parts of craniofacial skeleton which remained unchanged after tooth loss. Pointing to the reliability and objectivity of cephalometric determination of VDO in edentulous patients various authors[2–6,12–26] have proposed it for optimal determination of VDO in the treatment of edentulous patients. Starting from an assumption that reconstruction of the original VDO with complete dentures is a prerequisite for establishing the physiological muscular activity and optimal load distribution to the supporting tissues and thus long-term jaw relationship stability, we are facing a problem how to determine the proper VDO in edentulous patients with a lost jaw relationship[27–29].

The aim of this research was to establish precise cephalometric parameters of VDO, which could be used as objective guidelines in the prosthodontic therapy for exact control of the reconstructed vertical dimension of occlusion, early identification of errors and correction of VDO during complete denture manufacturing.

Materials and Methods

The study material consisted of 60 lateral cephalometric radiographs of subjects with complete natural dentition and class I skeletal jaw relationship. Lateral cephalograms were selected from the files of our dental school[22]. The ethic comittee of our dental school had approved this study. There were 30 male and 30 female subjects, aged from 20 to 29 years. The following inclusion criteria were used: subjects of Serbian nationality from the region of Vojvodina, full growth and development (age range: 20–29 years), facial and jaw symmetry; absence of orthodontic treatment, complete dentition in each jaw (lack of one tooth per quadrant was tolerated), class I skeletal jaw relationship (ANB angle within the limits of 2° to 4°). Cephalometric radiographs were made at the Clinic for Dentistry, Faculty of Medicine, in Novi Sad by the apparatus ORTOCEPH (Siemens, Germany). The radiographs were scanned using EPSON 1600 PRO and converted into digital form for computer processing.

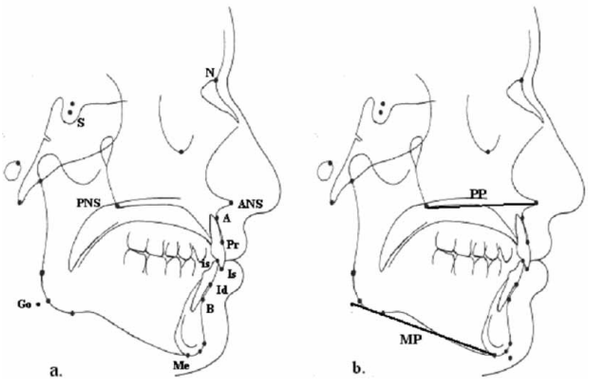


Fig. 1. a) Cephalometric points b) Cephalometric planes.

The following cephalometric points were used (Figure 1a): *Nasion* (N) – the most anterior point of the nasofrontal suture in the midsagittal plane, *Sella* (S) the middle of the *sella turcica* contour in the medial plane, *Subspinale* (A) – the deepest point of the shadow contour of the pre-maxilla in the medial plane, *Supramentale* (B) – the most posterior point of the shadow contour of mandibular alveolar process in the midsagittal plane, Anterior nasal spine (ANS) – tip of the anterior nasal spine, Posterior nasal spine (PNS) – tip of the posterior nasal spine, *Gonion* (Go) – the point at the intersection of the tangent of the corpus mandible lower border and the tangent of the *ramus* mandible posterior border, *Menton* (Me) – the lowest point of the shadow contour of the *symphysis* in the midsagittal plane, Incisor superior (Is) – the incisal tip of the upper central incisor, Incisor inferior (is) – the incisal tip of the lower central incisor, *Prosthion* (Pr) – the lowest point on the alveolar process above the upper incisors in the medial plane, *Infradentale* (Id) – the highest point on the alveolar process, between lower central incisors, in the medial plane. The following reference planes were used (Figure 1b): palatal plane (PP) – joins the ANS and PNS points, mandibular plane (MP) – joins the Me and Go points.

TABLE 1
RESULTS OF CEPHALOMETRIC ANALYSIS OF ANGULAR PARAMETERS USED IN DETERMINATION OF CLASS I SKELETAL JAW RELATIONSHIPS

Angular parameters	Sex	Xmin	Xmax	$\overline{X}$	SD	SE	CV(%)	Confidence interval 95%
SNA	F	75.7	87.2	82.043	3.1435	0.5744	3.8315	80.89–83.19
	M	78	87.4	82.0866	3.3996	0.6206	4.1414	80.84–83.32
SNB	F	73.5	86.2	80.113	2.9053	0.5304	3.6265	79.05–81.17
	M	75	87.7	80.3833	3.4794	0.6352	4.3285	79.11–81.65
ANB	F	2	4	2.926	0.5965	0.1454	20.3861	2.63–3.21
	M	2	4	2.7133	0.4112	0.1115	15.1549	2.49–2.95

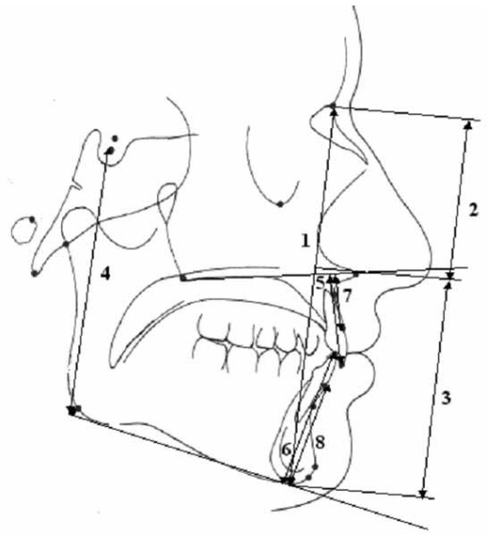
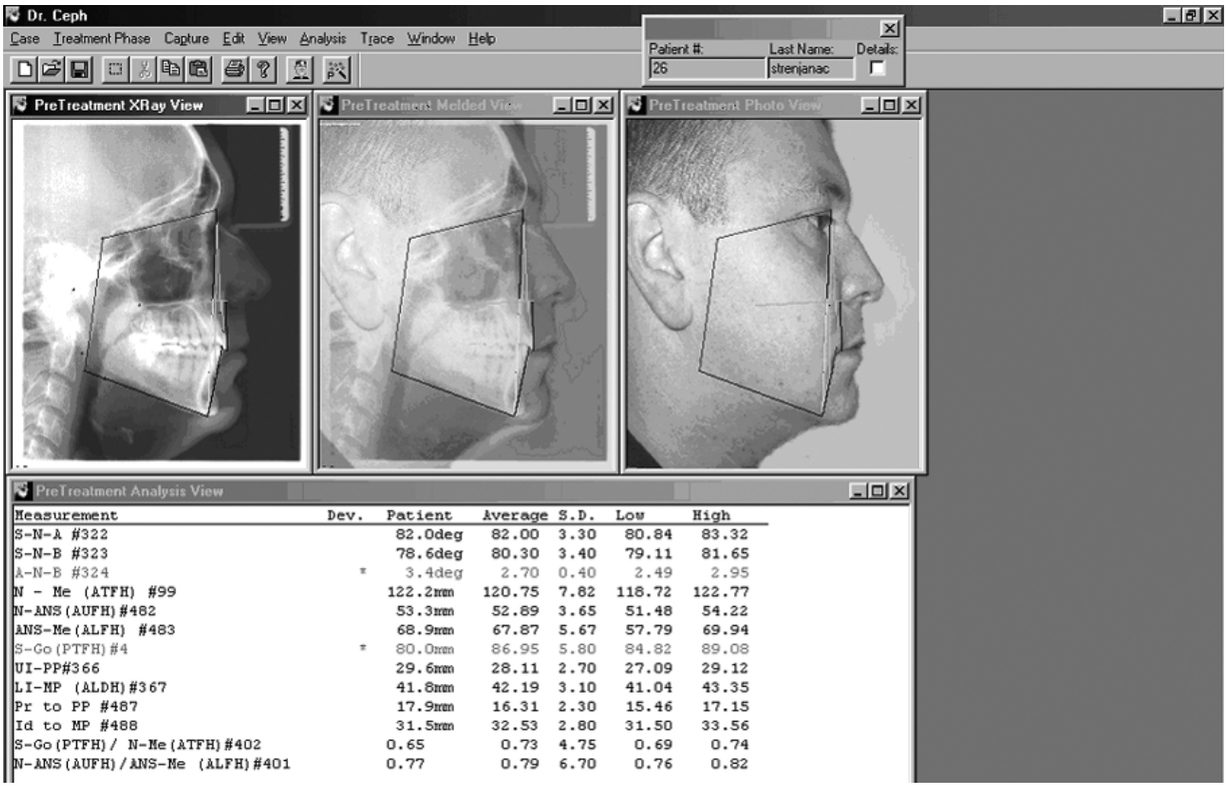


Fig. 2. Examined linear cephalometric parameters.

To determine skeletal jaw relationships (Table 1), the following angular cephalometric parameters were used: maxillary prognathism angle (SNA), mandibular prognathism angle (SNB), sagittal relationship between the maxilla and mandible (ANB)[23,24].

The examined linear skeletal cephalometric parameters were:

- Anterior total facial height (N-Me) – the linear distance between point *nasion* (N) and point *menton* (Me)[24,25](Figure 2, line 1),
- Posterior total facial height (S-Go) – the linear distance between point *sella* (S) and point *gonion* (Go)[24,25](Figure 2, line 4),
- Anterior upper facial height (N-ANS) – the linear distance between point *nasion* (N) and perpendicular projection of the anterior nasal spine point (ANS) to plane N-Me[26] (Figure 2, line 2),
- Anterior lower facial height (ANS-Me) – the linear distance between perpendicular projection of point anterior nasal spine (ANS) to plane N-Me and point *menton* (Me)[26] (Figure 2, line 3),
- Anterior upper dentoalveolar height (Is-ANS) – the vertical linear distance between point anterior nasal spine (ANS) and the tip of incisal edge of upper incisor (Is), perpendicularly to plane PP[17](Figure 2, line 5),
- Anterior lower dentoalveolar height (is-MP) – the vertical linear distance between the tip of the incisal edge of lower incisor (is) and plane MP, perpendicularly to plane MP[17](Figure 2, line 6),



Measurement	Dev.	Patient	Average	S.D.	Low	High
S-N-A #322		82.0deg	82.00	3.30	80.84	83.32
S-N-B #323		78.6deg	80.30	3.40	79.11	81.65
A-N-B #324	*	3.4deg	2.70	0.40	2.49	2.95
N - Me (ATFH) #99		122.2mm	120.75	7.82	118.72	122.77
N-ANS(AUFH)#482		53.3mm	52.89	3.65	51.48	54.22
ANS-Me(ALFH) #483		68.9mm	67.87	5.67	57.79	69.94
S-Go(PTFH)#4	*	80.0mm	86.95	5.80	84.82	89.08
UI-PP#366		29.6mm	28.11	2.70	27.09	29.12
LI-MP (ALDH)#367		41.8mm	42.19	3.10	41.04	43.35
Pr to PP #487		17.9mm	16.31	2.30	15.46	17.15
Id to MP #488		31.5mm	32.53	2.80	31.50	33.56
S-Go(PTFH)/ N-Me(ATFH)#402		0.65	0.73	4.75	0.69	0.74
N-ANS(AUFH)/ANS-Me (ALFH)#401		0.77	0.79	6.70	0.76	0.82

Fig. 3. Cephalometric analysis of parameters by »Dr. Ceph« computer software.

- Anterior upper alveolar height (Pr-PP) – the vertical linear distance between point *prosthion* (Pr) and plane PP, perpendicularly to plane PP[17](Figure 2, line 7),
- Anterior lower alveolar height (Id-MP) – the vertical linear distance between point *infradentale* (Id) and plane MP, perpendicularly to plane MP[17](Figure 2, line 8).

Examined proportions of certain linear parameters:

- S-Go:N-Me – ratio between the posterior and anterior total facial height[24,25]
- N-ANS:ANS-Me – ratio between the anterior upper and lower facial height[26]

Cephalometric analysis was done using a computer software, »Dr. Ceph« (FYI Technologies, GA, USA), version 9.7 (Figure 3). This program allows not only the use of a number of cephalometric points, variables, and analyses, but also makes possible the creation and definition of new ones. Precision and authenticity of measurement results and dimensions on radiographs was achieved by calibration. Picture quality adjustment (contrast and brightness) is a great advantage of this program. Enlargement, i.e. zooming in tiny details, provides precise demarcation of cephalometric points. If we incorporate standards- reference numerical values, for each variable, into the computer software during construction, the values of variables obtained by analysis will be differently colored, depending on the deviation from the standards. Microsoft Excel 2000 and SPSS 8.0 for Windows were used for statistical data processing.

Results and Discussion

The results of cephalometric analysis of the linear skeletal variables in women and men, and significance of differences between the sexes are shown in Table 2. In order to perform precise evaluation of craniofacial characteristics, two proportions of certain linear parameters were analyzed. Relationships between the obtained values of linear parameters provide a possibility of optimal insight into individual, proportional equalities or differences. Gathered results are multiplied by 100 and displayed as percentages. The proportion analysis of the linear parameters is shown in Table 3.

According to the literature data and many authors agree about that there is no accurate scientific or universally accepted method for precise determination of the vertical dimension of occlusion in the treatment of edentulous patients[5,27–33]. Various methods proposed for determination of the vertical dimension of occlusion in everyday practice are often recommended in combination with other methods[1–12]. Current concept of optimal or physiological VDO means existence of a range, not a fixed point or position. Many authors call it »comfort zone«[34–35], »vertical comfort range«[5], »occlusal zone«[36]. However, authors agree that the range differs from person to person. According to Morales, the concept of a vertical comfort range is generally accepted, explaining the dispersion of results or vice versa, dispersion of results may be explained by the concept of a vertical comfort range[37]. The aim of this study was to point out to the importance of using individual biological parameters in

TABLE 2
RESULTS OF CEPHALOMETRIC ANALYSIS OF LINEAR PARAMETERS IN WOMEN AND MEN AND SIGNIFICANCE OF DIFFERENCES BETWEEN THE SEXES

Linear parameters	Sex	Xmin	Xmax	$\overline{X}$	SD	SE	CV(%)	Confidence interval 95%	t-test p	
N–Me	F	99	118.3	112.723	5.6096	0.5561	5.0663	111.61–113.83	0.0000	***
	M	105.1	138.4	120.75	7.8259	1.0123	6.5351	118.72–122.77		
N–ANS	F	44.8	53.6	50.21	2.6586	0.9853	5.4025	48.15–52.261	0.0000	***
	M	47.5	59.6	52.8933	3.6558	0.6674	6.9116	51.48–54.22		
ANS–Me	F	50.4	70.7	61.506	5.0683	0.9253	8.2403	59.65–62.43	0.0002	***
	M	57.3	82.6	67.8733	5.6788	1.0368	8.4918	65.79–69.94		
S–Go	F	69.6	85.6	76.223	3.6789	0.6716	4.8264	74.87–77.56	0.0000	***
	M	72.7	99.6	86.9533	5.8260	1.0636	6.7001	84.82–89.08		
Is–PP	F	20.1	31.9	26.8366	2.5673	0.4887	9.5664	25.85–27.81	0.0698	n.s.
	M	21.3	35.7	28.11	2.7680	0.5053	9.8470	27.09–29.12		
is–MP	F	31.8	42.1	37.86	2.4370	0.4449	6.4368	36.97–38.74	0.0000	***
	M	37.8	50.4	42.1966	3.1666	0.5781	7.5043	41.04–43.35		
Pr–PP	F	9.3	22.1	15.9533	2.5408	0.4638	15.9264	15.02–16.88	0.5725	n.s.
	M	10.9	21.5	16.31	2.3219	0.4239	4.2360	15.46–17.15		
Id–MP	F	24.2	33.5	28.9966	2.1317	0.3891	7.3515	28.21–29.77	0.0000	***
	M	27.4	39.3	32.5333	2.8263	0.5160	8.6874	31.50–33.56		

Significance levels: *p<0.05, **p<0.01, ***p<0.001, n.s. – not significant

TABLE 3
RESULT OF PROPORTION ANALYSIS OF THE LINEAR PARAMETERS IN WOMEN AND MEN AND SIGNIFICANCE OF DIFFERENCES BETWEEN THE SEXES

Proportions of the linear parameters	Sex	Xmin	Xmax	$\overline{X}$	SD	SE	CV(%)	Confidence interval 95%	t test p	
S–Go:N–Me	F	62	78	68.9666	3.7183	0.6788	5.3914	67.60–70.32	0.0010	**
	M	63	81	72.8	4.7590	0.8688	6.5370	69.56–73.81		
N–ANS:ANS–Me	F	64	101	80.6333	8.3314	1.5211	10.3324	77.59–83.93	0.5200	n.s.
	M	67	93	79.3666	6.7388	1.2303	8.4907	76.02–81.72		

Significance levels: *p<0.05, **p<0.01, ***p<0.001, n.s. – not significant

prosthodontic diagnosis and treatment. We started from the fact that the optimum vertical dimension of occlusion in each individual case is the one which corresponds to the original one. It should also be mentioned that biological parameters established in foreign populations can be applied in our population only for global estimates of craniofacial skeleton development, but precise analyses should be done using data gathered by cephalometric analysis in our population[24,38]. Most of established parameters refer to the Caucasian population of Anglo-Saxon origin, considering the fact that major individual differences in mankind and in morphological features have been found, these parameters cannot be used for other races or ethnic groups without modification. The intention was to determine and analyze vertical craniofacial relationships in Serbian population with natural dentition and class I skeletal jaw relationship, inhabiting the Vojvodina region, in order to test the applicability of the existing biometric standards in our population.

The current methodology approach using »Dr. Ceph« (FYI Technologies, GA, USA), a modified computer software for cephalometric analysis which was used in this study, provides accurate, efficient and precise insight and imaging of the craniofacial complex, and permanent archiving of radiographs and analysis. Owing to the wide range of possibilities of this software, several analyses can be performed simultaneously, with easy and efficient differentiation of skeletal structures. »Dr. Ceph« is a computer program characterized by simple and easy image manipulation supported by software tools and operations; nevertheless, dentists are an important factor of success because they need to be familiar with the computer program and the technique itself. Owing to the abovementioned possibilities of this method, its introduction into everyday practice would represent a practical and favorable tool for success evaluation in rehabilitation of edentulous patients, as well as in evaluation of changes and results of prosthodontic treatment in these patients.

Comparing results of such investigations performed in examinees with natural dentition and class I skeletal jaw relationship, with biometric standards established by authors of cephalometric analyses, differences originating primarily from ethnic and population morphological variability were analyzed. Statistical analysis of data obtained from this study showed statistically significant differences between sexes (Table 2) in almost all linear dimensions (N–Me, N–ANS, ANS–Me, S–Go, is–MP, Id–MP) and in the relationship between the posterior and anterior total facial height (S–Go:N–Me). The values of these parameters were significantly higher in male subjects. Baring this in mind, it is very important to compare these values in the corresponding sexes, that is to consider sex differences when reconstructing VDO in the treatment of edentulous patients. A statistically significant difference between sexes was not found in two linear parameters (Pr–PP, Is–PP) and in the ratio between the upper and lower anterior facial heights (N–ANS:ANS–Me). The ratio between the posterior and anterior total facial heights (S–Go:N–Me, ♀ $\overline{X}$=68.96%, ♂ $\overline{X}$ =72.8%, Table 3) is higher compared to the biometric standards (62–65%)[25]. This points to the horizontal dentofacial developmental growth, because the obtained values were over 65%. Linear dimensions have been presented as proportions or ratios to allow easy comparison with other structures, since in this way correct dimensions are obtained. The proportions between the anterior upper and lower facial heights (N–ANS:ANS–Me, ♂ $\overline{X}$ =79.36%, ♀ $\overline{X}$= 80.63%, Table 3) were within normal values in both sexes (74%–84%)[26]. The established differences regarding the examined parameter were not statistically significant between sexes. Our results show that facial harmony exists both in men and in women. Statistical analysis was used to determine the 95% confidence intervals (Table 2 and 3) calculated on the probability level of 95% of examinees with natural dentition and class I skeletal jaw relationship. When calculating these intervals, the intention was not to obtain a set of fixed measures, but intervals of the most frequent morphological characteristics of the skeletal class I jaw relationship. Using 95% confidence intervals as vertical craniofacial morphological indicators can help to precisely determine the optimum VDO in each individual case. Furthermore, these intervals can help the dentists in their practice to adjust the VDO to some other factors of greater importance in the particular case.

Conclusion

Cephalometric studies of subjects with complete natural dentition included in this investigation provided important and specific data for optimal reconstruction of VDO in the treatment of edentulous patients. The obtained values may be used as objective parameters in pros-

thodontic treatment for exact control of the reconstructed vertical dimension of occlusion, detection of errors, correction of the vertical dimension of occlusion during complete denture manufacturing, and longitudinal follow-up and evaluation of changes of VDO in edentulous patients, as well as changes in the complete denture supporting tissues. Statistical analysis of data obtained from this study showed statistically significant differences between sexes in almost all linear dimensions and in the relationship between the posterior and anterior total facial height. These parameters were much higher in male examinees. Highly significant differences ($p<0.001$) between the sexes were established in regard to anterior total facial height (N–Me, ♀ $\overline{X}$=120.75mm, ♂ $\overline{X}$ = 112.72mm) and the anterior lower facial height (ANS–Me, ♂ $\overline{X}$= 67.87mm, ♀ $\overline{X}$=61.50mm). By evaluation of the craniofacial complex in subjects with natural dentition, horizontal dentofacial developmental growth was established in the examined sample and it was based on the relationship between the posterior and anterior total facial height (S–Go:N–Me, ♀ $\overline{X}$=68.96%, ♂ $\overline{X}$=72.8%). The proportions of the upper and lower anterior facial heights (N–ANS:ANS–Me, ♂ $\overline{X}$=79.36%, ♀ $\overline{X}$=80.63%) were within normal values in both sexes. Facial harmony existed both in men and women. Considering the concept of optimum or physiological VDO, which is defined as a range, not a fixed point, confidence intervals of vertical craniofacial morphologic parameters have been established in subjects with natural dentition for the purpose of direct examination of obtained values in edentulous patients after determination of VDO using clinical methods.

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RENDGENKRANIOMETRIJSKI POKAZATELJI VERTIKALNE DIMENZIJE OKLUZIJE

SAŽETAK

Cilj istraživanja je bio da se predloži adekvatna metoda i utvrde precizni rendgenkraniometrijski pokazatelji vertikalne dimenzije okluzije (VDO) koji bi mogli poslužiti kao objektivne smjernice u protetskoj terapiji za egzaktno kontroliranje rekonstruirane vertikalne dimenzije okluzije, otkrivanje grešaka i korekciju vertikalne dimenzije okluzije u procesu izrade totalnih proteza. Materijal koji je korišten u istraživanjima činilo je ukupno šezdeset telerendgen snimaka načinjenih kod ispitanika sa očuvanom prirodnom denticijom i skeletnim odnosom vilica klase I srpske populacije sa područja Vojvodine. Bilo je trideset ispitanika muškog spola i trideset ženskog spola, starosnog doba od 20 do 29 godina. Za analizu telerendgen snimaka korišten je kompjuterski program »Dr. Ceph« (FYI Technologies,GA,USA). Ren-

dgenkraniometrijska istraživanja kod osoba sa prirodnom denticijom u okviru ove studije pružaju važne i konkretne parametre za optimalnu rekonstrukciju VDO u terapiji bezubih pacijenata. Analizirajući kraniofacijalni kompleks ispitanika sa očuvanom prirodnom denticijom utvrđen je horizontalan tip rasta lica kao karakterističan za ispitivani uzorak što je utvrđeno na osnovu odnosa zadnje i prednje totalne visine lica (S–Go:N–Me, ♀ $\overline{X}$=68,96%, ♂ $\overline{X}$=72,8%), vrijednosti ovih pokazatelja znatno su veće kod ispitanika muškog spola. Visoke signifikantne razlike ($p<0,001$) između spolova utvrđene su kod prednje totalne visine lica (N–Me, ♂ $\overline{X}$=120,75 mm, ♀ $\overline{X}$=112,72 mm) i prednje donje visine lica (ANS–Me, ♂ $\overline{X}$=67,87 mm, ♀ $\overline{X}$=61,50 mm). Vrijednosti proporcije gornje i donje prednje visine lica (N–ANS: ANS–Me, ♂ $\overline{X}$=79,36%, ♀ $\overline{X}$=80,63%) kreću se u rasponu normalnih vrijednosti kod oba spola. Sklad lica postoji i kod muškaraca i kod žena.