COMPUTER PROGRAM FOR DIGITAL DATA ANALYSIS OF FACEBOW RECORDS – PART II

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Abstract. *The aim of the study was to perform a comparative data analysis of the values of sagittal condylar path and arrow point angle, obtained through measurements based on facebow records, by applying two methods: manual and digital by using the Mini-Maxi Facebow Analyzer computer program. **Material and method:** The program was tested through processing the data of 101 subjects (52 men and 49 women). The left and right sagittal condylar path was registered by using the Mini-Maxi facebow and the mandibular central position was determined by intraoral graphic registration. The data of each subject were entered into the program and the individual values of the registered parameters were calculated. Then, a comparative statistical analysis of the data obtained by the conventional manual measurement with a protractor and the computer program was performed. **Results:** The mean value of the sagittal condylar path obtained through the computer program was 34.89° for the right side and 35.86° for the left side. The mean value of the arrow point angle obtained through the computer program was 107.52°. The differences between the data for men and women were not statistically significant ($p < 0.05$). **Conclusions:** The computer program provides an accurate analysis of facebow records and assists in determining individual patient's movement parameters of the lower jaw. The comparative analysis of the accuracy of parameters obtained through conventional and digital measurements demonstrates the high product reliability of the computer program.*

Key words: facebow; digital analysis; sagittal condylar pathway; arrow point angle

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INTRODUCTION

The complicated character of mandibular combined movements, resulting from incongruence of temporomandibular joints, significantly hinders the construction of reproducing devices and apparatuses. Over the years, there have been attempts to accurately reproduce the jaw movements on articulators. The semi-adjustable articulator is probably the most appropriate type of dental articulators [3]. In the case of required complete oral reha-

bilitation, it is suitable to use the fully adjustable articulator. These types of articulators can duplicate all eccentric paths, so a precision centric position can be developed and maintained [6]. The reliability of the methods for articulator programming is vital for the accuracy of occlusion [11].

Semi-adjustable articulator programming requires defining the path of condylar guidance and the Bennett's angle, whereas at present, interocclusal records and the Hanau formula [2] are most frequently used. With fully adjustable articulators, however, we could

program the individual values of a greater number of parameters, such as sagittal condylar path, lateral condylar path of both the operational and balancing side in two dimensions – progressive and immediate lateral relocation, retrusive condyle path etc. [8, 14].

Articulators with mean values allow adjustment of the sagittal condylar path, as the mean value recommended for setting up the articulator is 30° and the fixed mean value of the intercondylar axis is 110 mm [9]. A number of scientific researches on sagittal condylar path have reported different mean values varying between 30° and 42° [1, 15]. Johnson [10] found mean sagittal condylar path values of 32° for the left side and 31.5° for the right side. Other authors [16] have reported that the average value of condylar guidance obtained by the interocclusal method is 34.71° for the right side and 35.00° for the left side. The average value of condylar guidance obtained by the radiographic method is 36.68° for the right side and 38.18° for the left side [16].

According to dos Santos JJr., Nelson S. and Nowlin T. [4], extraoral tracing measurements of sagittal protrusive condylar path give higher values with less variation than the intraoral wax protrusive method.

Klein [12] has described many differences in condylar morphology that may influence mandibular movements and require individual patient determination.

The most exact and popular methods for determining the sagittal condylar path include the use of a facebow [10]. For this purpose, the auricular type of facebow becomes more and more applicable in daily practice.

The precise transfer of registered data and the accurate articulator programming is essential for the precise simulation of functional movements. Mishra A. and Palaskar J. [13] compared the effect of direct and indirect transfer of condylar guidance values obtained with a semi-adjustable articulator, and used a cephalometric analysis to control the data. The average values of condylar guidance obtained through direct transfer, indirect transfer and cephalometric analysis were 24.93°, 27.66° and 32.73°, respectively. The average value obtained through indirect facebow transfers was closer to the value found by lateral cephalograms [13].

Another very important parameter for denture quality is the determination of mandibular central position. Centric and eccentric relations of the mandible can be recorded through the intraoral or positional wax method, graphic recordings, functional recordings, and cephalometrics [17].

Most frequently, this is done through the method of intraoral graphic registration, by using the intraoral reg-

istering plates by Gerber. The central position is fixed onto the top of the arrow point angle, as the position defined in this way coincides with the central relation [7]. The accuracy of pre-articulation steps, such as impressions, interocclusal records, and facebow transfers, is very important [18, 19, 20]. If inaccuracy occurs at any stage of the dental cast mounting procedure, the dental prosthesis would not fit functionally [5].

The aim of the study was to perform a comparative data analysis of the values of sagittal condylar path and arrow point angle, obtained through measurements based on facebow records, by applying two methods: manual and digital by using the Mini-Maxi Facebow Analyzer computer program.

MATERIAL AND METHODS

After intraoral examination, 101 subjects (52 men and 49 women) were found eligible to the study, based on the following criteria: preserved natural dentition with at least 28 teeth, orthognathic bite, no prosthetic restorations, no mandibular joint- and masticatory muscle-related complaints.

By using the Mini-Maxi facebow, we recorded the left and right sagittal condylar path (Fig. 1).

The determination of the sagittal condylar path was performed three times and recorded on the patient's registration card with a 0.2 mm fineliner (Fig. 2).

Manual measurement was performed on the patient's registration card by using a protractor of the sagittal condylar path slope in degrees (Fig. 3).

We also determined the mandibular central position by using intraoral graphic registration with intraoral registering plates (Fig. 4).

Manual measurements were also performed on the intraoral registering plates using a protractor of the arrow point angle in degrees (Fig. 5).

Fig. 1. Positioning of the "Face-bow Mini-Maxi" on the patient

Fig. 2. Recording of sagittal condylar pathway

Fig. 3. Manual measurement via protractor of the slope of the sagittal condylar pathway in degrees

Fig. 4. Intraoral graphic registration with assistance of the intraoral registering plates – movements on the left and on the right

Fig. 5. Record of an arrow point angle

In order to minimize the subjective errors, the registrations were performed by one and the same investigator. The data of each subject were entered into the program and the individual values of the registered parameters were calculated once again.

The digital data analysis of the values of sagittal condylar path was performed through two measurement options, automatic and manual, provided by computer program. After selecting the manual option, the user should mark with the mouse two points in the registrant's section designated for determining the sagittal condylar path.

Then, a comparative statistical analysis of the data obtained by the conventional manual measurements and the computer program was performed, with the size of the sagittal condylar path and the arrow point angle in degrees. For this purpose, we used the parametric Student's t-test.

RESULTS

Table 1 presents the values of the right sagittal condylar path, obtained by the conventional manual measurements and the computer program with automatic and manual options.

Table 1. Values in degree of the sagittal condylar pathway, on the right, established via three methods of measurement

Sagittal condylar pathway on the right						
Method of measurement	Group	Men		Women		Total
		N = 52		N = 49		N = 101
		Mean	SD	Mean	SD	Mean SD
Manual		35.46	5.98	34.00	6.09	34.75 6.04
Software, automatic option		35.64	6.00	34.03	5.99	34.89 5.99
Software, manual option		35.66	5.94	34.06	6.04	34.88 6.01

The mean value of the right sagittal condylar path, obtained by the conventional manual measurements, was 34.75° (± 6.04), 35.46° (± 5.98) for men and 34.00° (± 6.09) for women, respectively.

The mean value, obtained by the automatic option of the computer program, was 34.89° (± 5.99), 35.64° (± 6.00) for men and 34.03° (± 5.99) for women, respectively.

The mean value, obtained by the manual option of the computer program, was 34.88° (± 6.01), 35.66° (± 5.94) for men and 34.06° (± 6.04) for women, respectively.

The mean value of the left sagittal condylar path, obtained by the conventional manual measurements, was 35.68° (± 5.77), 37.12° (± 5.55) for men and 34.24° (± 5.66) for women, respectively.

The mean value, obtained by the automatic option of the computer program, was 35.86° (± 5.77), 37.33° (± 5.53) for men and 34.39° (± 5.65) for women, respectively.

The mean value, obtained by the manual option of the computer program, was 35.75° (± 5.74), 37.30° (± 5.47) for men and 34.20° (± 5.69) for women, respectively.

There was no statistically significant difference between the data of the right and left condylar sagittal path, for both men and women ($p > 0.05$).

The mean value of the arrow point angle, obtained by the conventional manual measurements, was

107.24° (± 8.41), 107.77° (± 9.28) for men and 106.70° (± 7.50) for women, respectively.

The mean value of the arrow point angle, obtained by the automatic option of the computer program, was 107.51° (± 8.36), 107.84° (± 9.18) for men and 107.19° (± 7.53) for women, respectively.

There was no statistically significant difference between the data of men and women ($p > 0.05$). The same was observed for the differences between the values of all studied parameters, obtained by both the automatic and manual option of the computer program.

However, statistically significant differences were found between the values, obtained by the conventional measurements using a protractor, and these calculated by the computer program.

DISCUSSION

The performed comparative analysis of the accuracy of parameters obtained through conventional and digital measurements demonstrates the high product reliability of the computer program. The differences between the two methods were between 0.01° and 0.5°, which is of no practical importance when interpreting the patient's individual parameters.

When analysing the data obtained by the manual and the automatic option of the program we found no statistically significant difference. For example, the dif-

Table 2. Values in degree of the sagittal condylar pathway, on the left, established via three methods of measurement

Sagittal condylar pathway on the left						
Method of measurement \ Group	Men		Women		Total	
	N = 52		N = 49		N = 101	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Manual	37.12	5.55	34.24	5.66	35.68	5.77
Automatic	37.33	5.53	34.39	5.65	35.86	5.77
Via software – option “Manual”	37.30	5.47	34.20	5.69	35.75	5.74

Table 3. Values in degree of the arrow point angle, established via two methods of measurement

Arrow point angle						
Method of measurement \ Group	Men		Women		Total	
	N = 52		N = 49		N = 101	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Manual	107.77	9.28	106.70	7.50	107.24	8.41
Automatic	107.84	9.18	107.19	7.53	107.51	8.36

ference between the mean values of the right sagittal condylar path obtained by the manual (34.88°) and the automatic (34.89°) option was 0.01° (Fig. 6).

The difference between the mean values of the left condylar sagittal path, obtained by the manual (35.75°) and the automatic (35.86°) option was 0.11°. The difference between the values of sagittal condylar path that were studied by the two program options varied in the range of 0.01° - 0.3°, which is of no practical value to the patient's prosthetic treatment. Both manual and automatic measurements of the program are an option of choice that offers a reliable result. This allows for the dental practitioner to select by preference the manner of program operation.

We compared the obtained mean values of the sagittal condylar pathway that corresponded to the average values between 30° and 42° presented in studies using different methodologies [1, 15].

Our results are most close to the average values reported by Prasad K.D., Shah N. and Hegde Ch. [16], obtained by the interocclusal method, which are 34.71° for the right and 35.00° for the left sagittal condylar path.

We share the opinion expressed by other authors [10] that there is no statistically significant difference between the individual values of the left and right

sagittal condylar path, as well as between the data of men and women.

The differences between the average values of the arrow point angle obtained by the two methods of measuring vary within 0.3°, which also is of no practical importance for the prosthetic treatment (Fig.7).

The informative value of the vector's position and the size of the arrow point angle were not studied sufficiently and the development of a large database by using the computer program would be beneficial for future scientific researches.

CONCLUSIONS

1. The mean value of the sagittal condylar path, obtained by the computer program is 34.89° for the right side and 35.86° for the left side. The differences between the data are not statistically significant.
2. The mean value of the arrow point angle, obtained by the computer program is 107.52°.
3. The computer program provides an accurate analysis of facebow records and assists in determining individual patient's movement parameters of the lower jaw.

Fig. 6. Size of the sagittal condylar pathway obtained through three methods of measuring

Fig. 7. Size of the arrow point angle obtained by two methods of measuring

4. The performed comparative analysis of the accuracy of parameters obtained by the computer program and the conventional manual method demonstrates the high product reliability of the computer program.

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