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A New Method For Selecting Maxillary Anterior Artificial Teeth In Complete Dental Prostheses

Development of a Data Processing Program for ArtificialTeeth Selection

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Abstract:- One of the difficulties of fabricating complete dentures is selection of the appropriate size of artificial teeth, i.e. selection of maxillary anterior teeth, commonly known as reference guide teeth. Nowadays, many anatomical structures can be used as guides to choose teeth for completely edentulous patients. In the classical tooth selection method, the nasal septum that passes through nasal wings is taken as the reference. This method is used by dentists to select anterior maxillary teeth and is recommended by various prefabricated tooth manufacturers. This method's drawback is that measurements are taken on soft tissues, whose dimensions often change. The development of humans' skull structure is completed after the age of approximately 18 when the interpupillary distance (PD) becomes constant. Therefore, PD can be used to obtain the appropriate tooth structure when a suitable method for selecting anterior maxillary teeth is developed. The method proposed in this study is aimed at developing a method for determining mesiodistal diameters of maxillary anterior teeth using PD and then listing the most suitable teeth using a computer-aided program after entering measurement values and other data into the program. These measurement values and data are the PD, material selection for the teeth (acrylic or porcelain), face type and gender of the person. This original research study proposes a new method for selecting the most appropriate maxillary anterior teeth resembling natural teeth in terms of aesthetics and functionality during the construction phase of dental prostheses in completely edentulous patients.

Keywords:- *Complete Denture, Tooth Selection, Artificial Intelligance.*

I. INTRODUCTION

In completely edentulous patients, selection and implantation of the six maxillary anterior teeth to make prosthesis is an important criterion for providing aesthetic and phonetic requirements. The main purpose of prosthetic restoration or rehabilitation is to provide the natural form, function and aesthetics. Patients care about not only the function but also appearance of their prostheses. Achievement of a natural appearance in complete dentures is made possible by positioning the six maxillary anterior teeth closest to the natural teeth [1].

In the use of artificial teeth, the position and form of natural teeth should be preserved as much as possible. Aesthetics play a major role in selecting the six maxillary anterior teeth in completely edentulous patients, but these teeth should comply with the surrounding oral tissues in terms of dimensions, form and color. Incorrectly selected and arranged teeth present a noticeable and artificial prosthetic misfit. Teeth may not be always very smooth and straight. In fact, small asymmetric changes made in accordance with general features can help patients and their relatives to accept prostheses more easily [2]. Aesthetically appealing tooth selection and implantation require practical skills and theoretical knowledge. Various methods for implanting artificial teeth to preserve the natural appearance have been studied. Some researchers have used prostheses made of natural teeth to preserve their natural appearance [2]. One of the most difficult aspects during the construction of complete dentures is determination of dimensions of the maxillary anterior teeth, which is required in both patients with a non-aesthetic prosthesis and those who use prosthesis for the first time [3].

The arrangement of the front teeth (incisors) in the construction of complete dentures is affected by various factors. The validity of many methods has not been fully proven. It is inevitable for some prostheses to have a prominently artificial appearance. A universal method for tooth selection has not yet been developed [3]. Generally, dentists use one or more guides based on their experience.

Sellen et al. published a historical review for methods used to select artificial anterior teeth for the edentulous patient[4]. Several factors have been proposed as aids for artificial tooth selection, and numerous methods have been devised for the evaluation of reliable esthetic factors in determining artificial tooth form. Sellen et at. concluded that no universally reliable method of determining tooth form has been found in literature and the Williams classification is the most universally accepted method of determining anterior tooth form[5].

Some studies were conducted on dimensional relationships between some anatomical guides and artificial teeth. Such anatomical guides include the distance between the zygomatic arches, the philtrum width, face width, face height, nose width, the distance between the resting mouth corners, the difference between the position of the upper lip edge at rest and that when a patient is laughing, and the outer contours of the face. The following relationships were determined as a result of the studies: the philtrum width equals the sum of widths of upper central incisors; the upper central incisor width equals 1/4 of the nose width; the upper central incisor width equals 1/2 of the philtrum width; the upper central incisor width equals 1/16 of the inter-zygomatic width; the upper lateral incisor width equals 1/22 of the face width; the upper canine width equals 1/19 of the face width; the length of the upper central incisor equals 1/20 of the face height; the sum of the mesiodistal dimensions of the upper incisors (central + lateral + canine) equals 1/3 of the inter-zygomatic distance [6].

Another systematic review carried by Abduo studied the publised data on occlusal schemes for complete dentures[7]. The study was focused on the relation to morphology, the posterior teeth were either anatomical or flat. The posterior tooth arrangements showed conventional bilaterally balanced occlusion (CBBO), lingualized bilaterally balanced occlusion (LBBO), or monoplane occlusion (MO). The lateral occlusal guidance involved either balanced occlusion or anterior tooth–guided occlusion (ATGO). Conclusions: Within the limitations of this review, it can be concluded that anatomical teeth arranged in CBBO or LBBO are preferable to flat teeth arranged in MO. This is primarily related to patient acceptance. ATGO can also be considered for complete dentures.

Isa et al. investigated the relationship of the maxillary central incisors to the incisive papilla in wearers of complete dentures. In their sample of edentulous patients, the anterior teeth in complete dentures were positioned approximately 3 mm closer to the incisive papilla, as compared with the position of the central incisors in natural dentition, and did not duplicate the position of the natural anterior teeth[8].

The literature related to traditional biomechanical design and open/hygienic design of removable partial dentures-RPDs was discussed by Owal et al. and a consensus was reached for a greater attention tfor design principles that minimize the risks of tissue injury and plaque accumulation in accordance with modern concepts of preventive dentistry was recommended [9].

There are other publications in literature reviewed complete denture esthetics regarding the addresses the process of tooth selection mostly gleaned from the classic prosthodontic literature [10-15]. These principles, which were developed over the past century, coupled with state-of-the-art materials are artificial teeth enable contemporary dentists to fabricate complete dentures with a level of esthetics never before possible.

The size of the maxillary incisors is crucial because these are the most apparent teeth of a person when examined from the frontal side. The maxillary lateral incisors, by contrast, vary more in terms of dimension, shape and position than other maxillary teeth; this leads to the choice of the tooth from some standard dimensions. This study, on functional and aesthetic tooth selection in completely edentulous patients, investigated the correlation between the mesiodistal dimension of six maxillary anterior teeth and the interpupillary distance (PD), the general face type, and gender. The mesiodistal diameters of the anterior artificial teeth, resembling the natural teeth of a patient in terms of dimensions and form and aesthetically providing integrity to the general face appearance, were determined and selected using a computer-aided program. As a result, it is considered that problems dentists encounter while choosing teeth for prostheses will be considerably eliminated. This study also supports the development of a more accurate and practical reference computer program for dentists.

II. MATERIALS AND METHOD

The aim was to establish a correlation between the mesiodistal diameters of the maxillary anterior teeth and constant PD using a suitable equation and thus select the appropriate artificial dental prosthesis for patients who lost their teeth. When measurements were taken, attention was paid to ensuring that individuals of different ages did not lose any teeth and had no restoration in the upper jaw. Accordingly, PD measurements were taken from 57 individuals using a pupillometer. Ethical principles outlined in the Declaration of Helsinki were followed and participants were provided informed consent. Mesiodistal diameters of the maxillary anterior teeth were measured using a digital caliper with 1/20 mm precision. Besides these measurements, face types, age and gender of the same individuals were recorded. Measurements were taken from 57 students at Tekirdağ Namık Kemal University, Çorlu Faculty of Engineering, and studied in 9 different categories, namely women with the oval face type, square face type, triangular face type; all women; men with the oval face type, square face type and triangular face type; and all individuals. The following findings were obtained from the investigation of the relationship between PD and maxillary central, maxillary lateral, maxillary canine teeth and the total of these teeth.

In the investigation of the relationship between PD and maxillary anterior teeth, considering genders and facial types of individuals, the mesiodistal diameters of maxillary central, maxillary lateral and maxillary canine teeth were measured with a digital caliper with 1/20 mm precision. There was no dental disorder in the upper anterior teeth of the individuals, and the individuals did not receive any prosthetic treatment. Rounded facial lines are generally associated with femininity, whereas angular lines indicate masculinity. When considering harmony between the tooth form and environment, women's teeth can be more ovoid and thin. In the present study, the effect of an individual's gender was considered.

During profile determination, the most geometrically similar shape (square, ovoid, or triangular) of the face, an important factor in selecting the artificial tooth, was considered. The labiopalatinal contour of the tooth, whose labial contours were determined based on the frontal face shape, was determined according to the curve formed by combining the frontal, nasal base and gonion.

The algorithm logic of the computer program for tooth selection using a computer program is as follows. First, face type is entered from the patient's profile. Face types are divided into three categories: square, triangular and oval. Second, the patient's gender is entered. Finally, the patient's PD is entered. As a result of the study, the coefficient of the correlation between PD and mesiodistal diameters of the maxillary central, lateral and canine teeth is multiplied by PD, depending on the gender and face type of the individual. Thus, the teeth closest to the value calculated by the program are selected among the teeth of various dimensions recorded in the computer and then listed. Because different correlation values were calculated by the program for the maxillary central, lateral and canine teeth, depending on the face type, it listing the results based on the desired tooth was possible.

III. RESULTS

The measurement results for women of all face types (25) are listed in Tables 1 and 2.

Table 1: Descriptive statistics of women of all face types.

Variable	Mean ± standard deviation	Minimum	Maximum
PD	60.42 ± 0.43	56.00	64.00
S[m-d]	8.49 ± 0.09	7.74	9.31
L[m-d	6.48 ± 0.11	5.36	7.58
C[m-d]	7.24 ± 0.08	6.73	8.42
Total	22.22 ± 0.21	20.71	24.84
S[m-d]/P	0.1406 ± 0.0015	0.1271	0.1453
L[m-d]/P	0.1074 ± 0.0018	0.0893	0.1237
C[m-d]/P	0.1199 ± 0.0013	0.1100	0.1358
TOP/PD	0.3681 ± 0.0034	0.3429	0.3974

PD: interpupillary distance, S[m-d]: mesiodistal diameter of the maxillary central tooth, L[m-d]: mesiodistal diameter of the maxillary lateral tooth, C[m-d]: mesiodistal diameter of the maxillary canine tooth, Total: sum of mesiodistal diameters of maxillary central, lateral and canine teeth, S[m-d]/PD: ratio of mesiodistal diameter of the maxillary central tooth to PD, L[m-d]/PD: ratio of mesiodistal diameter of the maxillary lateral tooth to PD, C[m-d]/PD: ratio of mesiodistal diameter of the maxillary canine tooth to PD, TOP/PD: ratio of the sum of mesiodistal diameters of maxillary central, lateral and canine teeth to PD.

Table 2: Descriptive statistics of women of all face types.

	PD	Central	Lateral	Canine
Central	0.301			
	0.144			
Lateral	0.214	0.460		
	0.305	0.021		
Canine	0.423	0.245	0.174	
	0.035	0.237	0.405	
Total	0.416	0.777	0.792	0.607
	0.039	0.000	0.000	0.001

In all female patients together, there is a statistically significant correlation between PD and the canine tooth (0.423) and between PD and the total dimension of the three teeth (0.416) ($p < 0.05$). There is a significant correlation between the dimension each of the central, lateral, and canine teeth and the total of these tooth dimensions, with the correlation between the dimension of the lateral tooth and the total dimension being the highest.In all female patients, the dimension of the canine tooth is predicted using PD as follows:

Regression analysis: Canine regression over PD
Canine = 2.08 + 0.0854 × PD.

Although this prediction is statistically significant, it has an accuracy of 14.3%, which is not adequate. Contrarily, the prediction accuracy can be increased by increasing the number of patients. In all female patients, the total dimension of the three teeth is predicted using PD as follows:

Regression analysis: Total regression over PD
Total = 9.83 + 0.205 × PD.

This prediction is statistically significant, but it has an accuracy of 13.7%, which is low. The prediction accuracy can be increased by working with larger numbers of patients. In the present study, regression equations over canine and total tooth dimensions were investigated because only the correlation between these two values and PD was statistically significant.

The measurement results for men of all face types (32) are presented in Tables 3 and 4.

Table 1: Descriptive statistics of men of all face types.

Variable	Mean ± standard deviation	Minimum	Maximum
PD	61.90 ± 0.34	58.00	66.00
S[m-d]	8.58 ± 0.08	7.71	9.60
S[m-d]	6.63 ± 0.09	5.65	7.85
C[m-d]	7.51 ± 0.07	6.74	8.20
Total	22.73 ± 0.20	20.90	24.97
S[m-d]/P	0.1387 ± 0.0013	0.1253	0.1523
L[m-d]/P	0.1071 ± 0.0013	0.0950	0.1209
C[m-d]/P	0.1214 ± 0.0011	0.1106	0.1353
TOP/PD	0.3673 ± 0.0028	0.3398	0.3963

PD: interpupillary distance, S[m-d]: mesiodistal diameter of the maxillary central tooth, L[m-d]: mesiodistal diameter of the maxillary lateral tooth, C[m-d]: mesiodistal diameter of the maxillary canine tooth, Total: sum of mesiodistal diameters of maxillary central, lateral and canine teeth, S[m-d]/PD: ratio of mesiodistal diameter of the maxillary central tooth to PD, L[m-d]/PD: ratio of mesiodistal diameter of the maxillary lateral tooth to PD, C[m-d]/PD: ratio of mesiodistal diameter of the maxillary canine tooth to PD, TOP/PD: ratio of the sum of mesiodistal diameters of maxillary central, lateral and canine teeth to PD.

Table 4: Correlation relationships of tooth dimensions in all men.

	PD	Central	Lateral	Canine
Central	0.347			
	0.051			
Lateral	0.549	0.532		
	0.001	0.002		
Canine	0.332	0.371	0.507	
	0.063	0.036	0.003	
Total	0.517	0.793	0.865	0.752
	0.002	0.000	0.000	0.000

In all male patients, there is a statistically significant correlation between PD and the lateral tooth dimension (0.549) and between PD and total dimension of the three teeth (0.517) ($p < 0.05$).

Moreover, there is a significant correlation between each of the central, lateral, and canine tooth dimensions and the total of these tooth dimensions, with the correlation between the dimension of the lateral tooth and the total tooth dimension being the highest.

In all male patients, the dimension of the lateral tooth is predicted using PD as follows:

Regression analysis: Lateral regression over PD
Lateral = −2.71 + 0.151 × PD.

In all male patients, the total dimension of the three teeth is predicted using PD as follows:

Regression analysis: Total regression over PD
Total = 3.61 + 0.309 × PD.

The accuracy of this prediction was found to be 24.3%. The measurement results obtained for individuals of all face types (57) are presented in Tables 5 and 6.

Table 5: Descriptive statistics of individuals of all face types.

Variable	Mean ± standard deviation	Minimum	Maximum
PD	61.21 ± 0.28	56.00	66.00
S[m-d]	8.50 ± 0.06	7.19	9.60
L[m-d]	6.52 ± 0.07	5.36	7.85
C[m-d]	7.37 ± 0.05	6.20	8.42
Total	22.40 ± 0.16	19.22	25.04
S[m-d]/P	0.1390 ± 0.0011	0.1178	0.1582
L[m-d]/P	0.1066 ± 0.0012	0.0863	0.1282
C[m-d]/P	0.1206 ± 0.0010	0.1016	0.1423
TOP/PD	0.3663 ± 0.0028	0.3106	0.4244

PD: interpupillary distance, S[m-d]: mesiodistal diameter of the maxillary central tooth, L[m-d]: mesiodistal diameter of the maxillary lateral tooth, C[m-d]: mesiodistal diameter of the maxillary canine tooth, Total: sum of mesiodistal diameters of maxillary central, lateral and canine teeth, S[m-d]/PD: ratio of mesiodistal diameter of the maxillary central tooth to PD, L[m-d]/PD: ratio of mesiodistal diameter of the maxillary lateral tooth to PD, C[m-d]/PD: ratio of mesiodistal diameter of the maxillary canine tooth to PD, TOP/PD: ratio of the sum of mesiodistal diameters of maxillary central, lateral and canine teeth to PD.

Table 6: Correlation relationship of tooth dimensions in all individuals.

Central	PD	Central	Lateral	Canine
	0.133			
	0.289			
Lateral	0.145	0.605		
	0.250	0.000		
Canine	0.249	0.442	0.434	
	0.045	0.000	0.000	
Total	0.211	0.839	0.857	0.744
	0.091	0.000	0.000	0.000

In all individuals, there is a statistically significant positive correlation between PD and the canine tooth (0.045) ($p < 0.05$).

The dimension of the canine tooth is predicted using PD as follows:

Regression analysis: Canine regression over PD
Canine = 4.24 + 0.0513 × PD.

This accuracy of this prediction is 4.7%. Although this prediction accuracy is statistically significant, it is very low.

IV. DISCUSSION

The loss of natural teeth has psychological and physiological effects. To improve the aesthetics of individuals and functioning of teeth, the missing teeth should be rehabilitated using artificial materials such as prostheses. Material selection is an important factor in making environment-friendly prosthetic teeth with ideal functional properties. Selection and arrangement of anterior teeth in completely edentulous patients is a challenge for the dentist [16].

Various studies in the literature investigate methods for selecting prosthetic teeth. It is necessary for a dentist to know many biological and physical factors for each patient when the dentist selects artificial teeth. Some researchers have suggested use of anatomical measurements in the selection of guide anterior teeth. Those authors evaluated the philtrum width, inter-zygomatic width, face width, alveolar crest form, interalar width and face form with the aim of guiding the artificial teeth selection.

Anthropometric measurements can be beneficial in the selection of artificial teeth [16]. A study on the skull stated that the mesiodistal width of the maxillary central tooth can be determined by dividing the inter-zygomatic distance by 16 and that the total width of six maxillary anterior teeth can be estimated by dividing the inter-zygomatic distance by 3.3 [3].

Kem reported that anthropometric parameters are a helpful guide in tooth selection. For 509 skulls, he compared dimensions of the maxillary anterior teeth by measuring the distance between nasion and menton points, the inter-zygomatic distance and the distance between gonions [18].

Ciftci et al. studied the compatibility of the dimension, shape, form, color and implantation of the maxillary anterior teeth with general facial features, physical characteristics, age and gender of completely edentulous patients. They concluded that selection of anterior teeth was crucial for providing functional and aesthetic requirements and success of complete dentures compared with total edentulism cases [2].

The study performed by Guldag et al. investigated a relationship between the two upper buccal frenula and the six upper anterior teeth [16]. The study's statistical analysis indicated that there was a significant relationship between the buccal frenula and anterior teeth (Table 7).

Table 7: Correlation coefficients between the frenula and maxillary anterior teeth.

Total Tooth Distance	Correlation coefficient (R)	Significance (P)
Left Teeth	0.41	0.003
Right Teeth	0.35	0.012

However, use of buccal frenula as a guide in the selection of maxillary anterior teeth was considered to be insufficient [16].

Guldag et al. investigated the relationship among the inter-zygomatic distance, the distance between gonions and mesiodistal widths of the central teeth of a patient and between model and antero-posterior films and determined that the differences between the inter-zygomatic distance and mesiodistal widths of the central teeth were significant at $p < 0.05$. In face and model measurements, the ratio of the inter-zygomatic distance to the mesiodistal width of the central tooth was found to be 1/8.26. For the measurements on the film, this ratio was 1/8.19 [16].

In a study conducted by Sakar on 65 female and 58 male subjects, whose standardized frontal and profile photographs were taken, the following findings were obtained: The ratio of the mesiodistal width of the central to PD was 0.144; the ratio of the philtrum width to the mesiodistal width of the central was 0.445; the ratio of the mesiodistal width of the central to the nares distance was 0.366; the ratio of the mesiodistal width of the central to the eye width was 0.296; the ratio of the mesiodistal width of the central to the distance between the inner edges of eyes was 0.286; and the ratio of the mesiodistal width of the central to the distance between nasal wings was 0.248 [1].

According to Hoffman, if a straight ruler is placed on the edge of the eye and nasal wing and its extensions are marked on both sides on a properly shaped wax wall, then the distance between two marks is the distal of the canines [19]. Hoffman et al. compared the longest distance between nasal wings and the distance between the peaks of the canines and found a significant relationship between the two measurements. The following findings were obtained in a study on 80 subjects [19]. The study revealed that there was no significant relationship between the distance between the peaks of the canines and the longest width of nasal wings. The relationship between the nasal folds and the distance between the peaks of the canines was not significant, and the nose width was not a useful guide in the selection and arrangement of the artificial anterior teeth.

In 1905, Berry argued that the mesiodistal widths of the upper central teeth were 1/16 of the face width [20]. House confirmed Berry's finding [21]. Sears explained the relationship between the upper and lower teeth using the inter-zygomatic distance [22].

According to the findings of the present study, no evaluation could be made because there were only two data for women with square and triangular face types. The evaluation may not give reliable results because of the small number of observations.

In the women with the oval face type, statistically significant correlations were found between PD and canine tooth and total tooth dimensions. The regression equations using PD indicated that the canine tooth dimension could be estimated with accuracy of 15.3%, and the estimation of the total tooth dimension has 18.6% accuracy. In consideration of all women, statistically significant correlations were determined among PD and the canine tooth dimension and the total tooth dimension. The regression equations revealed that

the canine tooth dimension and the total tooth dimension could be estimated with 14.3% and 13.7% accuracies, respectively. Because there were only two data for men with the square face type, no evaluation was made. The evaluation may not give reliable results because of the small number of observations. There was no statistically significant correlation between PD values and measured and calculated tooth dimensions in the men with the oval face type ($p > 0.05$). Statistically significant correlations were found among PD values and lateral, canine and total tooth dimensions in the men with the triangular face type ($p < 0.05$). Regression analyses using PD indicated that the lateral, canine, and total tooth dimensions could be estimated with 33%, 28.9% and 35.5% accuracies, respectively.

When all men were evaluated, there were statistically significant correlations among PD and lateral and total tooth dimensions ($p < 0.05$). The regression analyses revealed that the lateral tooth dimension could be estimated with 27.8% accuracy, and the total tooth dimension was 24.3% accurate. In the evaluation of all individuals with all face types, a statistically significant correlation was found between PD and canine tooth (0.045) ($p < 0.05$). The regression analyses indicated that the canine tooth dimension could be determined with 4.7% accuracy.

V. CONCLUSION

In this study, with a different viewpoint, a new method was developed to provide the functional and aesthetic requirements and success of complete dentures compared with total edentulism cases, with the aim of contributing to the selection of the guide anterior teeth. Another purpose of the study was to help dentists in determining tooth dimensions through a combination of different methods.

Evaluation of all individuals together decreases the correlation values and the strength of prediction based on regression. Evaluating women and men separately in the face type categories increases the accuracy of the results of the study. All analyses were made with 57 individuals; by contrast, the analyses made with more individuals are likely to increase the accuracy of the estimation. In general, the data for the individuals with the oval face type and the men with the triangular face type, as well as the estimation results based on correlation and regression, are significant. However, these results are not sufficient to be used in tooth selection; thus, this tooth selection method can be made unique by increasing the number of individuals under study. The analysis results of this study can be used as a supplementary reference for dentists to use with other methods in the selection of dental prostheses.

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- *Conflict of Interest*

The authors have no conflict of interest to declare.

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