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ORIGINAL RESEARCH ARTICLE

Machine Learning Based Software to Predict the Type of Gingival Recession Surgery

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Abstract

Purpose: The goal of this study is to identify the most important variables affecting gingival recession and to develop a machine learning -based software system using these variables.
Materials and Methods: 132 mandibular/maxillary right/left teeth #1, #2, #3, #4, and #5 were included in the study. Recession depth, recession width, width of keratinized gingiva, plaque index, buccogingival tissue thickness, frenulum position, and mobility were recorded before and 6 months after surgery. One of the following methods has been selected: Gingival unit graft, coronally advanced flap, coronally advanced flap+connective tissue graft, and coronally advanced flap+platelet-rich fibrin. Software system was developed to predict the type of gingival recession surgery.
Results: While the gingival unit graft group had the highest pre- and post-recession depth values, the coronally advanced flap group had the highest pre-recession width, pre-width of the keratinized gingiva, and post-width of the keratinized gingiva values. A significant difference was found between surgical type categories for all variables except gender, post-buccogingival tissue thickness, and post-frenulum position ($p<0.05$). Random Forest was found to be the best-performing method both for surgery categories and overall based on accuracy and F-measure. The accuracy value was found to be 90.0% for the gingival unit graft, 62.5% for the coronally advanced flap, 71.4% for the coronally advanced flap+connective tissue graft, and 97.8% for the coronally advanced flap+platelet-rich fibrin.
Conclusions: The machine learning software system could evaluate the data accumulated in the database using the decision trees method and predict the prognosis of surgical techniques to treat gingival recession. The software system developed will help physician determine the optimal treatment approach.

Keywords: Decision trees; Gingival recession; Machine learning; Mucogingival surgery; Predictive decision model

Introduction

Mucogingival deformities are a group of conditions that affect a large number of patients. Among the mucogingival deformities, lack of keratinized tissue and gingival recession are the most common problems.[1] Marginal tissue recession is characterized as the displacement of the soft tissue margin apical to the cementoenamel junction (CEJ).[2]

Numerous variables, like inflammation, trauma, tooth alignment, age, calculus deposition, and smoking, are believed to contribute to this disease. The absence of keratinized tissue is also considered a risk factor for gingival recessions and inflammation.[3] Several aspects of gingival recession make it clinically significant.[4–6] The presence of recession is esthetically unacceptable for many patients; dentin hypersensitivity may occur, the denuded root surfaces are exposed to the oral environment, and may be associated with carious and non-carious cervical lesions, such as abrasions or erosions.

For an accurate treatment strategy, the severity of gingival recessions should always be determined. Cairo et al. presented a treatment-oriented classification based on the interdental clinical attachment loss (CAL) score: Cairo Recession Type 1 (RT1), RT2, and RT3.[7] Various periodontal plastic surgical strategies have been introduced in gingival recession treatment. These include free gingival grafts (FGG), connective tissue grafts (CTG), guided tissue regeneration, and pedicle grafts. Even though nearly all of them de-

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livered positive clinical changes, different rates of success and consistency have been reported both between and within these procedures.[8,9] Numerous factors, including the width of the keratinized gingiva, cervical lesions, depth and width of gingival recession, buccal bone thickness, dental plaque, patient-related factors (such as age, gender, and smoking), gingival thickness, high frenulum attachment, and tooth mobility, influence the treatment outcome of gingival recessions.[10–15] Too many variables can induce gingival recession, making it difficult to predict the prognosis of recession surgery.

Machine learning refers to the process of extracting new, valuable, and undiscovered information from data sets. It is a joint effort of humans and computers.[16] It is also defined as the process of extracting previously unknown, potentially useful, and interesting information from large and often different data sources.[17,18] In practice, the most important purpose of machine learning is to make predictions. Prediction involves using variables in the dataset to predict unknown values of the dependent variable.[19]

To date, no studies have used machine-learning-based software to assess gingival recession and surgical approaches. The hypothesis of the study is that models created using machine learning are more successful in predicting the prognosis of recession surgery than classical statistical methods. The aim of this study is to determine the most important variables that affect gingival recession and to develop a machine-learning-based software system using these variables. The system has a dual purpose of serving as a database for patient information and as a decision support system for foreseeing the type of gingival recession surgery.

Material and Methods

Study Population and Study Design

This cross-sectional study included systemically healthy individuals who attended to Ankara University Faculty of Dentistry Department of Periodontology for gingival recession treatment and were scheduled for root closure surgery after the periodontal examination. The research was carried out in accordance with the Declaration of Helsinki of 1975, as revised in 2013, and the study design was authorized by the Ankara University Faculty of Dentistry Clinical Studies Ethics Committee (ethical approval number 36290600/96). This clinical investigation has been filed with Clinical Trials.gov (NCT04045808). All patients included in the study provided their consent after being fully informed.

The study included systemically healthy adult patients $\geq$18 years old who have incisors, first and second premolars in both jaws. Women who were pregnant or nursing, patients who were taking any medications that may affect periodontal tissues, and patients who had previously undergone periodontal surgery in the relevant region were excluded from the study. The research involved 132 teeth. Each patient underwent an initial phase of therapy, which included oral prophylaxis, root planing, oral hygiene instructions, and occlusal adjustment. Upon the completion of the initial examination and during Phase I periodontal therapy, the selected sites were randomly assigned to each one of the groups, 1, 2, 3, and 4, in accordance with a randomization list. The establishment of treatment groups, in which each patient receives a specific treatment choice, was conducted as follows:

1. Gingival unit graft (GUG) (Conventional free palatal graft modified with the involvement of marginal gingiva and papillary tissue). 2. Coronally advanced flap (CAF). 3. CAF+CTG. 4. CAF+platelet-rich fibrin (PRF).

Data Collection

All surgical procedures were carried out by either associates or PhD candidates. A single investigator blinded to the procedures conducted all of the measurements. At the baseline, the teeth and the type of recession were recorded. The research included central and lateral incisors, canines, and the first and second premolars. The classification method used in this manner by Cairo et al.[7] was utilized for recessions and graded as RT1: Gingival recession with no loss of interproximal attachment. RT2: Gingival recession associated with loss of interproximal attachment. The amount of loss of interproximal attachment was less than or equal to the buccal attachment loss. RT3: Gingival recession associated with loss of interproximal attachment. The amount of interproximal attachment was higher than the buccal attachment loss.

The following periodontal variables were recorded before and 6 months after surgery by a periodontal probe . Recession depth (RD) was measured as the distance between CEJ and the most apical point of the gingival margin at the mid-buccal point of the teeth involved. Recession width (RW) was measured at the CEJ mid-facially, and values were recorded in mm. The distance between the mucogingival line and the gingival margin was measured for the width of the keratinized gingiva (WKG). With the help of a periodontal probe, the mobile alveolar mucosa was moved towards the keratinized gingiva, and the mucogingival line was determined (Roll technique). Plaque index (PI) was recorded from the mid-buccal, mesiobuccal, and distobuccal regions of each tooth undergoing periodontal surgery, and average values were recorded.[20] Buccogingival tissue thickness (BTT) was measured with the TRAN (probe transparency) method; the gingival biotype was considered thin if the outline of the probe was visible through the gingival margin from the sulcus and thick if the probe was not visible through the sulcus.[21] Frenulum position was named according to its location as a mucosal attachment, gingival attachment, or papillary attachment. Mobility was detected by using an instrument (e.g., a mirror handle) on either side of the tooth after applying a controlled force and was scored on a scale of 0–3.[22]

Software Methodology

The creation of a decision support system based on the best-performing machine learning method was planned. The developed software system calculates an estimated success rate for each criterion based on the type of surgery for the 132 tooth regions, aligned with the specified pre- and post-operative data. At the same time, it aims to estimate the success rate and percent closure of the surgery for each selected type of surgery. With the developed system, it is planned to record patient data and thus create a global database for use in future research. It is thought that the performance of the system will increase by adding the post-surgical data to the model in addition to the pre-surgical data.

Sample Size

Since there is no similar study in the literature, the sample size is calculated based on the effect size. When the effect size of the difference between GUG, CAF, CAF+CTG, and CAF+PRF surgery types in terms of preoperative WKG is taken as 0.3, when the sample size is calculated using the One Way ANOVA test with a significance level of 0.05 and a power of 0.80, a minimum of 128 teeth was found sufficient for the study.

Statistical Analysis

WEKA 3.7 and SPSS 11.5 were used to evaluate the data. Mean ± standard deviation and median (minimum-maximum) were used

Table 1. Descriptive statistics for quantitative variables according to the types of gingival recession surgery

Variables		Surgery Type				p value
		GUG	CAF	CAF+CTG	CAF+PRF	
Age	Mean ± SD	30.69±7.95	46.75±12.48	39.78±11.72	45.29±10.82	<0.001
	Median	29.00	50.00	35.50	50.00	
	(Min-Max)	(18.00-46.00)	(27.00-58.00)	(21.00-60.00)	(18.00-59.00)	
Pre-RD(mm)	Mean ± SD	3.85±1.43	2.07±0.51	3.11±1.09	2.23±0.95	<0.001
	Median	4.00	2.00	3.00	2.00	
	(Min-Max)	(1.50-7.00)	(1.00-3.00)	(1.00-6.00)	(1.00-4.00)	
Post-RD(mm)	Mean ± SD	1.97±1.45	1.68±0.82	0.91±0.97	1.24±0.99	<0.001
	Median	1.50	2.00	0.75	1.00	
	(Min-Max)	(0.00-6.00)	(0.50-3.00)	(0.00-3.50)	(0.00-4.00)	
Pre-RW(mm)	Mean ± SD	2.74±0.68	3.57±1.27	3.46±0.85	3.23±0.91	<0.001
	Median	2.50	3.25	3.50	3.00	
	(Min-Max)	(1.50-4.50)	(1.50-5.50)	(2.00-6.00)	(2.00-5.00)	
Post-RW(mm)	Mean ± SD	1.87±0.98	2.86±1.57	1.84±1.35	2.13±1.21	0.150
	Median	2.00	3.00	2.00	2.00	
	(Min-Max)	(0.00-4.50)	(0.50-5.50)	(0.00-4.00)	(0.00-4.00)	
Pre-WKG(mm)	Mean ± SD	2.01±0.99	5.71±2.02	3.29±1.44	5.26±1.97	<0.001
	Median	2.00	7.00	3.00	5.00	
	(Min-Max)	(0.00-4.00)	(2.00-8.00)	(0.50-7.00)	(2.00-10.00)	
Post-WKG(mm)	Mean ± SD	5.44±1.77	6.14±1.51	5.01±1.39	5.89±1.76	0.048
	Median	6.00	7.00	5.00	6.00	
	(Min-Max)	(2.00-11.00)	(3.00-8.00)	(3.00-8.00)	(3.00-10.00)	

Abbreviations: GUG, Gingival unit graft; CAF, Coronally advanced flap; CAF+CTG, Coronally advanced flap + connective tissue graft; CAF+PRF, Coronally advanced flap + platelet rich fibrin; Pre-RD, Preoperative recession depth; Post-RD, Postoperative recession depth; Pre-RW, Preoperative recession width; Post-RW, Postoperative recession width; Pre-WKG, Preoperative width of the keratinized gingiva; Post-WKG, Postoperative width of the keratinized gingiva. SD: Standard deviation, Min: Minimum, Max: Maximum.

for quantitative variables, and the number of cases (percentage) wasused for qualitative variables. The Kruskal Wallis H test was used to determine whether there is a difference between the categories of qualitative variables with more than three categories for the quantitative variable. The Chi-square test was used to examine the relationship between two qualitative variables. The statistical significance level was taken as 0.05. Machine learning methods of Logistic Regression, Multilayer Perceptron, and Random Forest were used for data analysis. The data set was evaluated by using the 10-fold Cross-Validation test option. Accuracy, F-measure, Precision, Recall, and ROC Area were used as the evaluation criteria.

Results

Comparisons of quantitative variables for recession surgery type were analyzed in Table 1, and a significant difference was found between surgical type categories for all variables except post-RW ($p<0.05$). Patients undergoing CAF surgery had the highest mean age, while patients undergoing GUG surgery had the lowest mean age. While the GUG surgery group had the highest pre-RD and post-RD values, the CAF surgery group had the highest pre-RW, pre-WKG, and post-WKG values.

Comparisons of qualitative variables for recession surgery type were analyzed in Table 2, and a significant difference was found between surgical type categories for all variables except gender, post-BTT, and post-frenulum position ($p<0.05$). The majority of surgical procedures were performed on the central teeth, or at least the second premolars. While the majority of GUG procedures were performed on the central teeth, the majority of CAF, CAF+CTG, and CAF+PRF procedures were performed on the canine teeth.

The GUG group had greater RT1 and RT2 recessions (40.0% and 48.9%, respectively), but the CAF and CAF+CTG groups had high RT1 recessions (75.0% and 88.0%, respectively). No RT2 or RT3 recessions occurred in the CAF+PRF group. Smokers were mostly seen in the CAF+PRF group. PI values and BTT thickness increased for all groups following the surgeries. Frenulum position was observed to be mucosal following surgeries in both the CAF+CTG and CAF+PRF groups. Before surgery, Miller 1 and 2 mobility were only observed in the GUG group (Table 2).

Information Gain Attribute Evaluation and Gain Ratio Attribute Evaluation methods were employed because there were too many variables in the data set. By using these methods, the importance of the variables and the values they added to the data set were examined. The variables, which were determined to be insignificant by two methods and considered to be unimportant as clinical information, were excluded from the data set. A total of 15 variables (14 independent variables and 1 dependent variable) remained finally. These variables were gender, age, pre-RD, pre-RW, pre-WKG, post-WKG, pre-BTT, post-BTT, pre-PI, post-PI, pre-frenulum position, post-frenulum position, smoking status, teeth, and recession surgery type. Percentages of variable importance according to dependent variable recession surgery type were given in Fig. 1.

The data set was analyzed using different machine learning techniques, and the performance criteria of the best three methods were given in Table 3. The Random Forest method was observed to be the best performing in both surgery categories and overall based on accuracy and F-measure, which are the most widely used performance criteria in the literature (overall, ACC:0.864, F-measure: 0.859). On a surgery categories basis, accuracy value was found to be 90.0% for GUG, 62.5% for CAF, 71.4% for CAF+CTG, and 97.8% for CAF+PRF.

The number of trees for the Random Forest method was determined to be 100, and the structure of one of these trees, J48, is given in Fig. 2. The tree structure gives information about which type of surgery should be chosen when and under what conditions. For instance, when the tree structure is examined, it is seen that the operation type should be chosen as CAF+CTG. When the pre-frenulum position is mucosal, the pre-PI value is 0, the recession type is RT1, and the pre-BTT type is thin.

According to our findings, the Random Forest method was used to create the software system, and the system screenshots were given in Fig. 3 and Fig. 4. Fig. 5 and Fig. 6 show case photographs taken after GUG surgery and CAF+CTG surgery, respectively.

Table 2. Descriptive statistics for qualitative variables according to the types of gingival recession

Variables		Surgery Type				p value
		GUG n (%)	CAF n (%)	CAF+CTG n (%)	CAF+PRF n (%)	
Gender	Male	10 (22.2)	2 (12.5)	14 (28.0)	9 (42.9)	0.174[a]
	Female	35 (77.8)	14 (87.5)	36 (72.0)	12 (57.1)	
Teeth	Central	45 (100.0)	4 (25.0)	8 (16.0)	3 (14.3)	<0.001[b]
	Lateral	0 (0.0)	2 (12.5)	7 (14.0)	5 (23.8)	
	Canine	0 (0.0)	6 (37.5)	16 (32.0)	8 (38.1)	
	1st premolar	0 (0.0)	3 (18.8)	13 (26.0)	4 (19.0)	
	2nd premolar	0 (0.0)	1 (6.2)	6 (12.0)	1 (4.8)	
Type of recession	RT1	18 (40.0)	12 (75.0)	44 (88.0)	21 (100.0)	<0.001[b]
	RT2	22 (48.9)	0 (0.0)	3 (6.0)	0 (0.0)	
	RT3	5 (11.1)	4 (25.0)	3 (6.0)	0 (0.0)	
Smoking status	Non-Smoker	30 (66.7)	15 (93.8)	41 (82.0)	7 (33.3)	<0.001[b]
	<10 per day	2 (4.4)	1 (6.2)	0 (0.0)	2 (9.5)	
	≥ 10 per day	13 (28.9)	0 (0.0)	9 (18.0)	12 (57.2)	
Pre-PI	0	17 (37.8)	14 (87.5)	42 (84.0)	4 (19.0)	<0.001[b]
	1	19 (42.2)	0 (0.0)	6 (12.0)	16 (76.2)	
	2	6 (13.3)	2 (12.5)	2 (4.0)	1 (4.8)	
	3	3 (6.7)	0 (0.0)	0 (0.0)	0 (0.0)	
Post-PI	0	7 (15.6)	5 (31.2)	32 (64.0)	12 (57.1)	<0.001[b]
	1	11 (24.4)	11 (68.8)	9 (18.0)	4 (19.0)	
	2	9 (20.0)	0 (0.0)	4 (8.0)	5 (23.8)	
	3	18 (40.0)	0 (0.0)	5 (10.0)	0 (0.0)	
Pre-BTT	Thick	14 (31.1)	13 (81.2)	21 (42.0)	13 (61.9)	0.002[a]
	Thin	31 (68.9)	3 (18.8)	29 (58.0)	8 (38.1)	
Post-BTT	Thick	45 (100.0)	16 (100.0)	50 (100.0)	20 (95.2)	0.280[b]
	Thin	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.8)	
Pre-frenulum position	Mucosal	3 (6.7)	13 (81.2)	16 (76.2)	16 (76.2)	<0.001[b]
	Gingival	38 (84.4)	3 (18.8)	5 (23.8)	5 (23.8)	
	Papillary	4 (8.9)	0 (0.0)	0 (0.0)	0 (0.0)	
Post-frenulum position	Mucosal	44 (97.8)	13 (81.2)	44 (88.0)	19 (90.5)	0.114[b]
	Gingival	1 (2.2)	3 (18.8)	6 (12.0)	2 (9.5)	
Pre-mobility	0	27 (62.8)	14 (100.0)	50 (100.0)	19 (100.0)	<0.001[b]
	1	12 (27.9)	0 (0.0)	0 (0.0)	0 (0.0)	
	2	4 (9.3)	0 (0.0)	0 (0.0)	0 (0.0)	
Post-mobility	0	28 (65.1)	14 (100.0)	50 (100.0)	19 (100.0)	<0.001[b]
	1	15 (34.9)	0 (0.0)	0 (0.0)	0 (0.0)	

Abbreviations: GUG, Gingival unit graft; CAF, Coronally advanced flap; CAF+CTG, Coronally advanced flap + connective tissue graft; CAF+PRF, Coronally advanced flap + platelet rich fibrin; Pre-PI, Preoperative plaque index; Post-PI, Postoperative plaque index; Pre-BTT, Preoperative buccogingival tissue thickness; Post-BTT, Postoperative buccogingival tissue thickness; Pre- frenulum position, Preoperative frenulum position; Post- frenulum position, Postoperative frenulum position; Pre-mobility, Preoperative mobility; Post-mobility, Postoperative mobility. Statistical significant (p<0.05). a Chi-squared test, b Fisher exact test.

Table 3. Performance Measures for Machine Learning Methods

Methods	Surgery Type	Performance Measures				
		Accuracy	F-measure	Precision	Recall	ROC Area
Logistic Regression	GUG	0.780	0.772	0.765	0.780	0.867
	CAF	0.625	0.645	0.667	0.625	0.881
	CAF+CTG	0.714	0.652	0.600	0.714	0.892
	CAF+PRF	0.778	0.814	0.854	0.778	0.912
	Overall	0.750	0.752	0.757	0.750	0.888
Multilayer Perceptron	GUG	0.800	0.800	0.800	0.800	0.898
	CAF	0.762	0.800	0.842	0.762	0.962
	CAF+CTG	0.838	0.833	0.829	0.838	0.895
	CAF+PRF	0.911	0.882	0.854	0.911	0.957
	Overall	0.811	0.809	0.809	0.811	0.925
Random Forest	GUG	0.900	0.865	0.833	0.900	0.910
	CAF	0.625	0.741	0.909	0.625	0.966
	CAF+CTG	0.714	0.769	0.833	0.714	0.941
	CAF+PRF	0.978	0.936	0.898	0.978	0.986
	Overall	0.864	0.859	0.865	0.864	0.948

Abbreviations: GUG: Gingival unit graft, CAF: Coronally advanced flap, CAF+CTG: Coronally advanced flap + connective tissue graft, CAF+PRF: Coronally advanced flap + platelet rich fibrin.

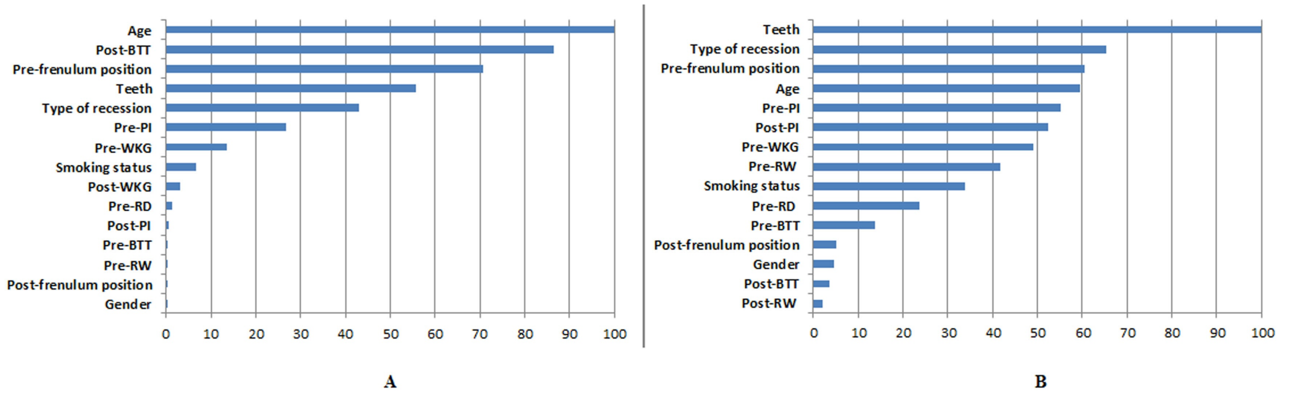

Figure 1A: Gain Ratio Attribute Eval., Figure 1B: Information Gain Attribute Eval. Abbreviations: Post-BTT, Postoperative buccogingival tissue thickness; Pre-frenulum position, Preoperative frenulum position; Pre-PI, Preoperative plaque index; Pre-WKG, Preoperative width of the keratinized gingiva; Post-WKG, Postoperative width of the keratinized gingiva; Pre-RD, Preoperative recession depth; Post-PI, Postoperative plaque index; Pre-BTT, Preoperative buccogingival tissue thickness; Pre-RW, Preoperative recession width; Post- frenulum position, Postoperative frenulum position.

Figure 1. Variable Importance Test Results for Recession Surgery Type. A: Gain Ratio Attribute Eval., B: Information Gain Attribute Eval

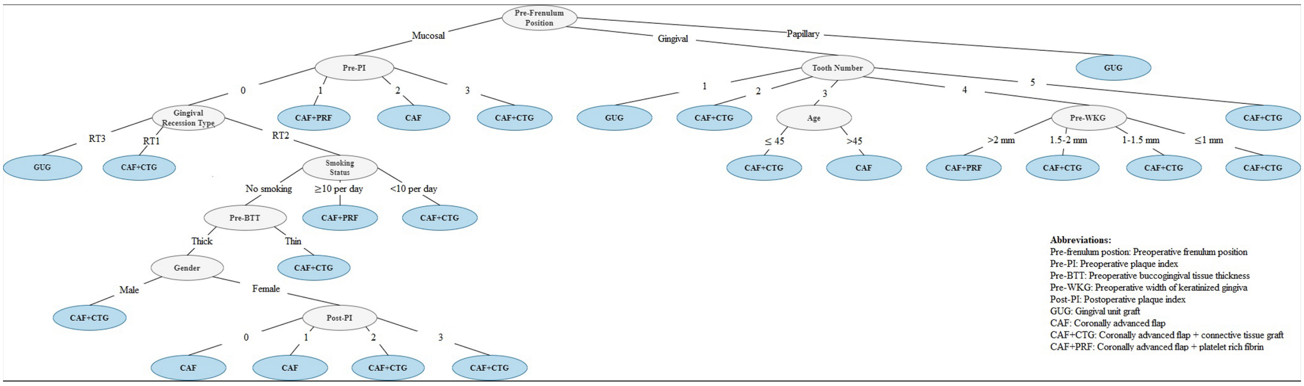

Figure 2. Tree Diagram of the Random Forest Method

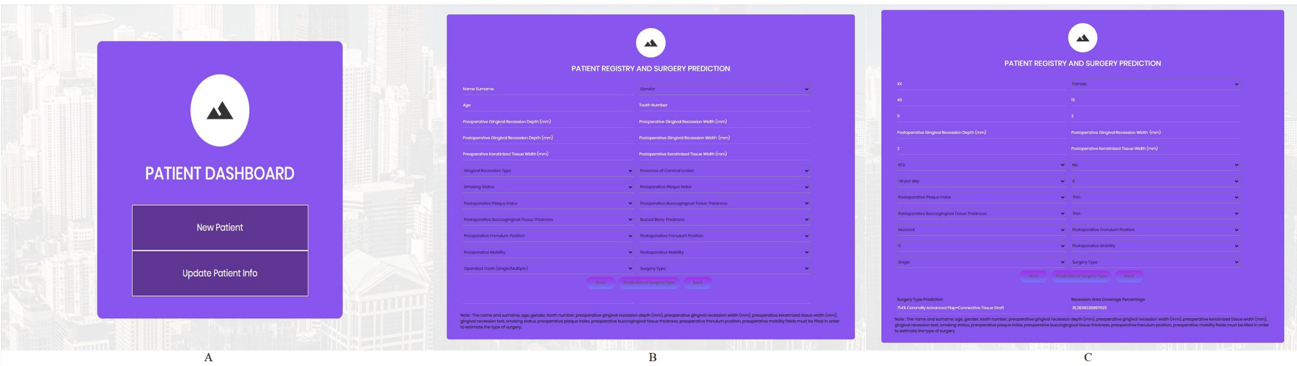

Figure 3. Software Outputs for New Patient. A: Patient Dashboard, B: New Patient Entry, C: New Patient Prediction

Discussion

Gingival recessions have been treated with various strategies over the past 30 years, including FGG, subepithelial or connective tissue grafts, CAF, non-absorbable membranes or absorbable membranes, enamel matrix derivatives, and CAF mixed with platelet-rich gel.[23–30] When estimating the prognosis in cases with gingival recession, clinicians are limited in their ability to select the type of surgery indicated by the existing categories. In this study, the data from four surgery types (GUG, CAF, CAF+CTG, and CAF+PRF) with the highest root closure success rates were incorporated into a computer program that utilized a machine learning approach to predict prognosis. Our study resulted in the development of a software system that can handle a great variety of clinical factors. Although this program allows us to predict surgery prognosis with a high degree of accuracy using the current data, it will also enable machine learning software system to estimate surgery prognosis with an even higher degree of precision when new data becomes available. In our report, we listed the characteristics that influence the kind of surgery, and we instructed a computer program that does statistical calculations and employs machine learning (Decision Trees) to select a prognosis estimation and operation type. In this study, 132 tooth sites with gingival recessions were evaluated using 15 criteria. Our study's machine learning-based computer program utilizes the Decision Trees method's multivariate model, which is accomplished by assessing 15 independent variables simultane-

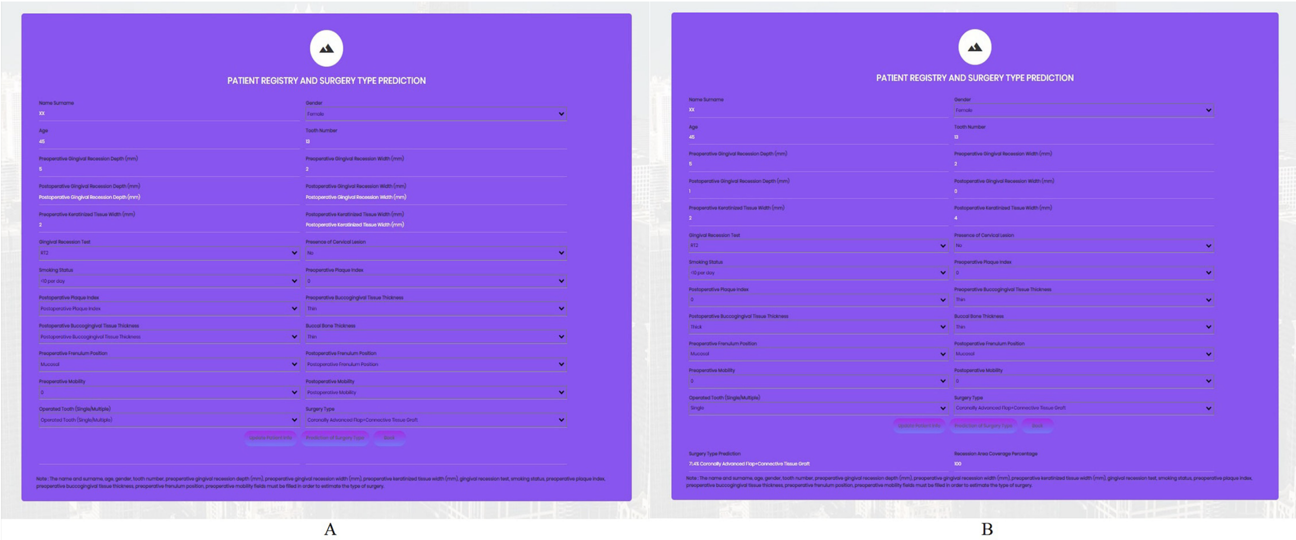

Figure 4. Software Outputs for Update Patient. A: Update Patient Entry, B: Update Patient Prediction

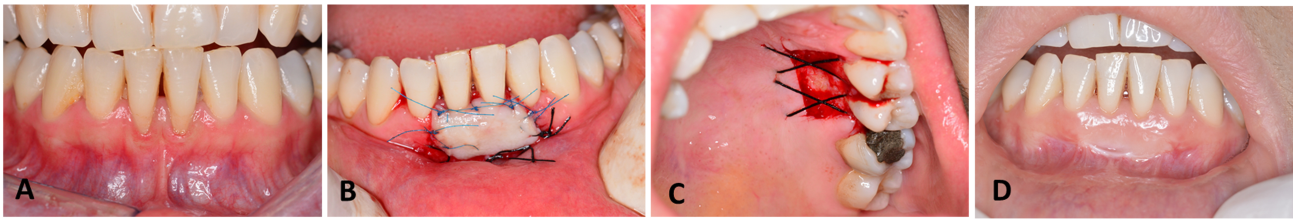

Figure 5. Views of the Gingival Unit Graft Surgery. A: Baseline, B: Gingival Unit Graft Suture, C: Donor Site (Palatinal View), D: 6-months Follow-up

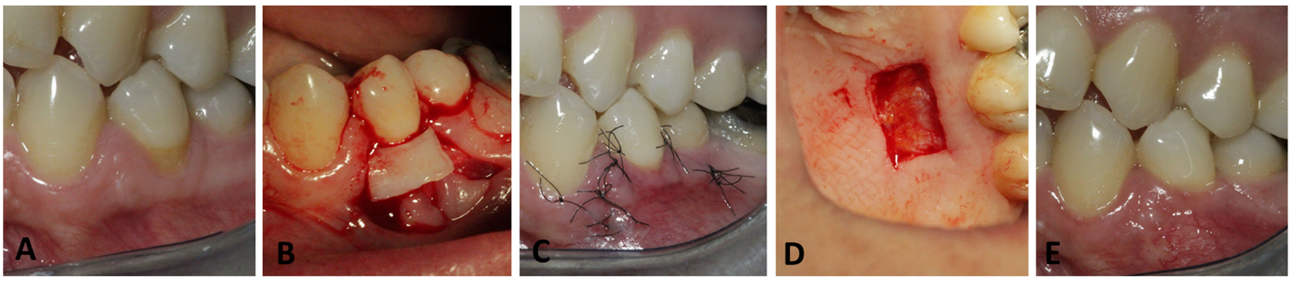

Figure 6. Views of the Coronally Advanced Flap+Connective Tissue Graft Surgery. A: Baseline, B: Flap Elevation and Connective Tissue Graft, C: Coronally Advanced Flap Suture, D: Donor Site (Palatinal View), E: 6-months Follow-u

ously. The Decision Trees technique develops a prediction model by integrating these 15 factors. Since just one of these factors would be inadequate for making a prediction, a prediction procedure must be run with all the factors present.

In order to determine the likelihood of developing conditions like diabetes and heart disease, scientists and physician have created a number of risk assessment techniques.[31–33] In 2002, Page et al. published a research in the field of periodontology using a similar calculation approach to ours.[34] They developed a computer-based approach for calculating periodontal disease risk (PRC). In contrast to the software employed in this research, our study utilizes statistical decision trees. Compared to previous statistical approaches, this method (Random Forest) gives a single choice on behalf of the population by integrating the findings of numerous classifiers in identifying the most appropriate treatment option, resulting in more accurate estimations.[35] Persson et al. found that, while assessing periodontal risk, professional physician exhibited greater variability and heterogeneity than PRC software.[36] Their findings showed that utilizing risk ratings to make treatment decisions might lead to treatment errors and that an objective instrument like the PRC could be advantageous. A similar machine-learning-software system was developed, allowing clinicians to anticipate the success rates of treatment techniques to be employed in our study for the treatment of gingival recession. By utilizing data from a variety of dental applications, it is conceivable that the system we developed might be applied to other disciplines. In a study by Covani et al.[37], a software system was used to analyze dominant genes to be associated with periodontitis and Type 2 diabetes mellitus, and Fan et al.[38] used the Decision Trees statistical method to create a model to predict dental prognosis. In health care, decision trees are often used to assist physician in making diagnostic and treatment decisions based on evidence.[39] These tools might also assist public health officials and service providers in selecting evidence-based policies and implementation strategies and in identifying areas where further research is required.[40]

Significant variables have been found to impact the prognosis of root closure surgeries on the location and teeth to be operated on in our study. The contribution of the computer program to the predictability of the tooth to be operated on is crucial. In a study evaluating the parameters influencing the prognosis of root closure procedures used to treat gingival recession, Aroca et al.[41] discovered that surgeries conducted on the upper jaw were more successful than surgeries performed on the lower jaw. In this study, we found that there were substantial disparities in teeth between the groups. In the future, we will be able to remark on other teeth, and when new data is uploaded into the program by other clinicians, this may alter the variable significance table. The GUG group had the highest increase in WKG after surgery, with a mean of 3.43 mm. The free gingival graft has been successfully used to increase the amount of keratinized tissue in periodontal plastic surgery procedures. Kuru and Yıldırım[25] found a root closure rate of 91.6% for GUG surgery and 87% for free gingival graft surgery. GUG with the gingival margin was included in our analysis since there aren't many studies and data on free gingival graft procedures in the literature. The mean WKG increased by 0.43 mm after surgery in the CAF group, 1.72 mm in the CAF+CTG group, and 0.63 mm in the CAF+PRF group. In 114 gingival recessions, Kuis et al.[42] compared CAF+CTG surgery to CAF surgery. They found a 2.4±0.6 mm average increase in keratinized tissue with CAF+CTG surgery. When the widths of keratinized tissue are assessed prior to surgery in our study, it has been shown that GUG surgery is preferred when the keratinized tissue is less than 2 mm thick. Literature considers free gingival graft surgery to be the gold standard for increasing the quantity of keratinized tissue.[10,43,44]

There were substantial differences in smoking between the groups. In the CAF+PRF group, 57.2% of patients were smokers, whereas the CAF group has no smokers. In a study comparing smokers and nonsmokers, the success rate of CTG root surface closure was 83.3% in smokers and 58% in nonsmokers.[45] In our study, the CAF+CTG group exhibited the highest percentage of root surface closure. Following this are the GUG, CAF+PRF, and CAF groups. In the CAF+PRF group, smoking appeared to have a negative effect on root closure. The low proportion of root closure in the non-smoker CAF group is not just attributable to smoking but may also be due to a number of other variables. While there was a substantial variation in smoking status across the surgical groups in our investigation, these differences contributed considerably to the accuracy of the computer program's prediction.

In our investigation, PI ratings before and after surgery were considerably different. Numerous studies have indicated that the higher the root closure success rates following gingival recession treatments, the lower the PI scores.[46,47] This relevance will assist computer programs in predicting results.

BTT can have an effect on gingival recession. Ercan et al.[48] reported a substantial positive link between gingival phenotype and buccal alveolar bone thickness. In our study, there was a statistically significant difference in BTT between the groups prior to surgery. BTT data were inputted into a computer program to be able to make predictions. Certain forms of maxillary frenulum have an influence on periodontal health, according to Mirko et al..[49] In our study, the location of the frenulum before surgery was substantially different between groups. In 97.8% of the postoperative GUG group, the frenulum was detected in the mucosal position. However, following surgery, the proportion of the frenulum in the mucosal position increased in the CAF+CTG and CAF+PRF groups. It is believed that these disparities have a substantial influence on the capacity of software to predict and function.

Bernimoulin et al. (1977) evaluated tooth mobility during flap surgery.[50] They discovered no correlation between gingival recession and tooth mobility. Where Kerry et al.[51] showed a reduction in tooth mobility one month following non-surgical therapy, but an increase six months after flap surgery. In our study, only the GUG group had Miller 1 and 2 mobility before surgery, and after surgery they had either Miller 1 or no mobility. The system allows for the addition of mobility data, enabling the user to make long-term projections.

On the basis of the most generally used performance criteria in the literature, accuracy and F-measure, random forest was determined to have the best category and overall performance (overall, ACC: 0.864, F-measure: 0.859). GUG accuracy is 90%, CAF accuracy is 62.5 percent, CAF+CTG accuracy is 71%, and CAF+PRF accuracy is 97.8 percent on a categorical basis. The random forest method was used to create the system, according to our findings. If the big data sets remain in their existing condition, the above-mentioned percentage will be utilized to estimate the prediction rates for the future operations, and the system will determine what percentage and kind of surgery the newly added data set may imply. Each new data set, in addition to post-operative measurement data, will be added; by increasing these rates over the present levels, the program will have a greater possibility of predicting. In medicine, risk calculators for illnesses such as heart disease and diabetes have been created.[31–33] Although it is anticipated that entering data on surgical results conducted by different physician may impair standardization, it was determined that this cannot be a limitation because the system will run primarily on data added over time by different surgeons. Gingival recession is one of the most challenging situations in periodontology for physician to address. The forms of surgery recommended by the present classifications can be used to predict prognosis, with some restrictions. With the aid of the system developed in this study, surgical operation prognosis may be predicted with a high level of precision.

Conclusion

The machine-learning-based-software system, created based on the Random Forest machine learning method, in the study can predict the recession surgery type and success of surgical procedures used to treat gingival recession. The software developed as a part of this study was converted to a web-based application. Using machine learning, the software may generate prognostic predictions for each physician based on data sets produced from data entered by doctors on the website. The accuracy of the prognosis improves as more information is included. Scientists will be able to contribute to the development of a global database on gingival recession using the provided software.

Ethical Approval

This study was reviewed and approved by the Ethics Committee of the Faculty of Dentistry, Ankara University (Decision No: 36290600/96/2017). Informed consent was obtained from all participants.

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Author Contributions

Study Design : B.K. , E.U. , M.T.
Performed Surgical Procedures : B.K.
Performed Statistical Analysis : B.B.
Recorded Clinical Data : B.K.
Interpreted the Results : B.B. , C.O. , E.U.
Developed the Machine Learning : B.B.
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Conflict of Interest

The authors declare that they have no conflicts of interest.

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