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CREATING DATABASE WITH IMAGE PROCESSING METHODS FROM DENTAL X-RAY

Emre AVUÇLU [1] *, Fatih BAŞÇİFTÇİ [2]

[1] *Aksaray University, Department of Software Engineering, Aksaray, Türkiye*

[2] *Selçuk University, Department of Computer Engineering, Konya, Türkiye*

**** Corresponding Author:*** *emreavuclu@aksaray.edu.tr*

ABSTRACT

The characteristic distinguishing features of a person define that person. With these characteristics, a person can be distinguished from other persons. Forensic sciences have to identify individuals in some cases. In identification, dental images are frequently used today, especially in age and gender determination procedures. In this study, a data base was created in which panoramic dental x-ray images could be used to identify people. By removing the borders from panoramic dental X-ray images, a total of 1313 dental images and 162 distinct tooth groups were generated. These images have undergone pre-processing to achieve improved results. Preprocessed images are saved in a folder. The preprocessed images are corrected with a novel and originally developed rotation algorithm. The application was developed in C # programming language.

Keywords: Dataset create, Computer programming, Panoramic graph, Image processing, X-ray images.

1 INTRODUCTION

Age estimation from teeth plays an important role in various fields. In forensic medicine, age estimation from teeth is an important tool, especially in identifying unidentified corpses. This method helps in cases such as determining the cause of death and finding missing persons. In anthropology, in the study of prehistoric human populations, age estimation from teeth provides information about the life span, health status and social structures of individuals [1].

In paleontology, examination of teeth is of critical importance in fossil findings, especially in determining the ages of early human species. In immigration and asylum, in some countries, age estimation from teeth can be used to determine the ages of immigrants and refugees without identity documents. This is especially important in terms of protecting children and correctly conducting legal processes. In orthodontics and dentistry, the developmental stages of teeth are used to monitor the growth and development processes of children. This helps in making appropriate orthodontic treatment plans. Age estimation from teeth is generally based on the growth, development and wear patterns of teeth [2]. The accuracy of identification methods can vary based on an individual's genetic and environmental factors. In forensic medicine, identification, which involves recognizing the characteristics of living or deceased individuals, is a critical concern. Identification may be necessary for various reasons, such as natural disasters, legal or forensic cases, with age determination being a vital component of this process [3-4]. Teeth are the structure that will be affected at the latest by external factors and physical factors. Teeth are also frequently found on the person after physical wear. Today, atlases are used in dental practice and forensic sciences for the prediction of age, showing the development and riding stages of the teeth. It is a method used in identification studies during mass disasters, particularly when there are numerous casualties [5]. The studies carried out to date in the forensic events show that the identification of the forensic sciences will remain a growing and popular field of occupation. Race, age, gender, physical properties are the identity parameters that the forensic sciences give priority [6]. They conducted various segmentation and identification procedures on dental X-ray images [7-9]. These analyses are an effective tool in identifying individuals and making correct decisions in social or legal situations. By using different methods of dental x-ray images [10-11], by measuring different areas of the tooth [12], by making measurements in young and pediatric teeth [13-17], age estimations for were made depending on the human skeletal size [18-19]. Avuçlu and Başçiftçi used artificial intelligence techniques to determine age and gender by preprocessing dental images [20-23].

In this study, the dental images acquired from panoramic dental x-rays were manually prepared. These images were first applied to image pre-processing. With these image processing techniques, a database was created to perform age and gender estimation from dental images. These images can be used not only to predict age and gender, but also to be used in other subjects such as classification, recognition and diagnosis in artificial intelligence techniques.

2 MATERIAL AND METHOD

In this study, the database consists of images obtained from the X-ray device shown in Figure 1.

Figure 1. Panoramic X-ray device.

Extracted tooth images are stored in the source folder. There are a number of procedures to create a database from dental images. The flow diagram showing the sequence of this operation is shown in Figure 2.

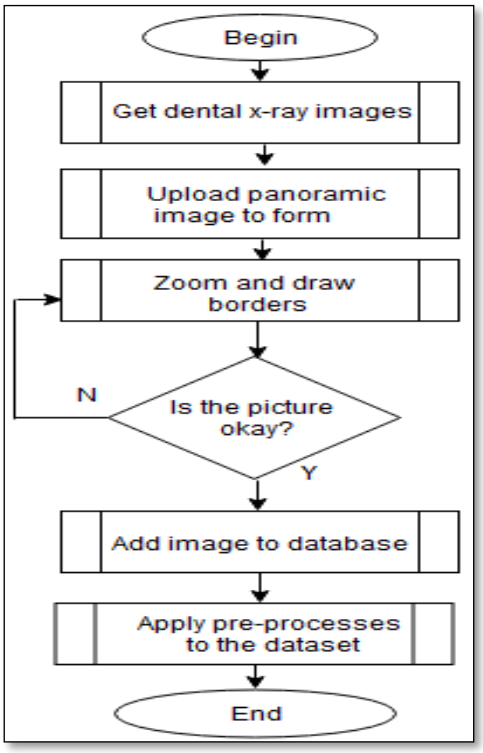


Figure 2. Flow diagram.

As shown in Figure 3., the teeth images are first applied to the methods. Thus, it is ensured that the images are of a certain standard quality. With otsu image thresholding method, tooth images are converted to binary form. The overall structure of the program is as shown in Figure 3.

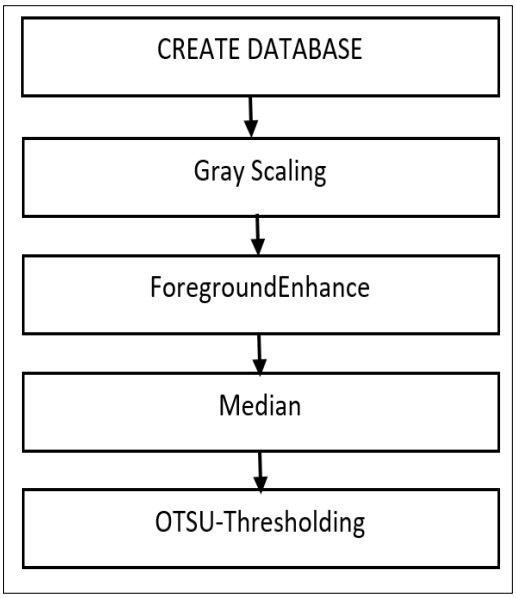


Figure 3. General Methodology.

Gray scale is a term used in image processing to describe a format that represents a color image as only black, white, and shades of gray in between. Such images are a single-channel format, where each pixel has only the light intensity.

Foreground enhance is a technique that aims to increase the visibility and distinctness of foreground objects or regions in an image. This process is used specifically to strengthen the differences between the background and the foreground in an image and to make foreground objects clearer.

Median filtering is a technique specifically designed to reduce noise. It is often preferred because it removes noise while preserving the edges.

Otsu Thresholding is an automatic binary image acquisition method used in image processing. This method is used to separate pixel values in an image into two classes (e.g., objects and background). Otsu Thresholding provides an effective solution, especially in cases where it is difficult to choose a specific threshold value.

2.1 Creating Dataset

Each of these recorded images was examined one by one and sturdy teeth were selected. When enumerating the teeth, the Universal Numbering System was used. Accordingly, the numbering of the teeth is as shown in Figure 4.

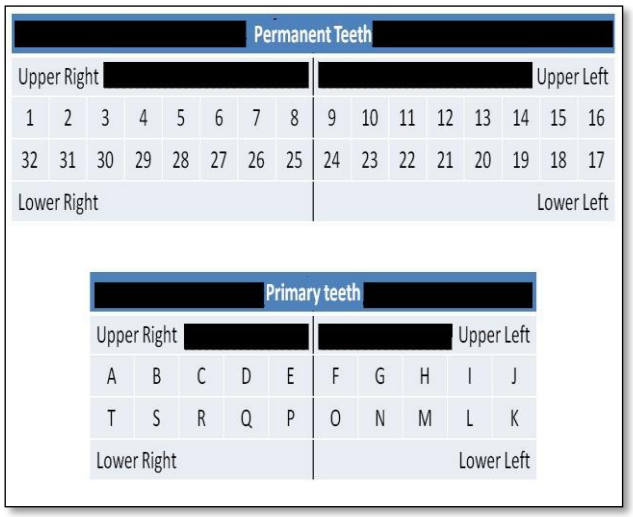


Figure 4. Dental Numbering System.

2.2 Zoom and Free Drawing Processes

The image zoom technique is used to accurately remove the boundaries of the tooth image. Zooming is the process of software incrementing an image at pixel dimensions. With the C # programming language, zooming, dimensioning and limiting operations on the tooth images can be performed. Digital zoom is used as in Figure 5.

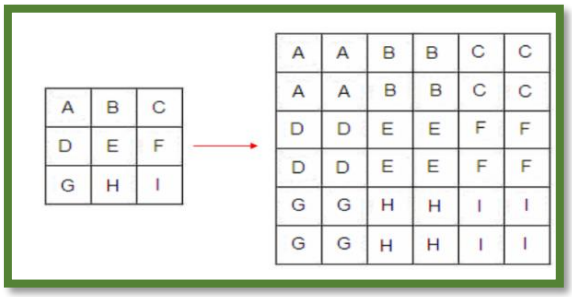
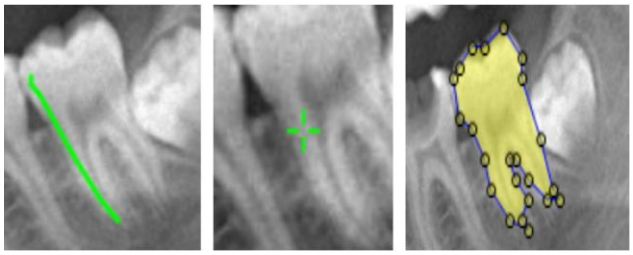


Figure 5. Zooming.

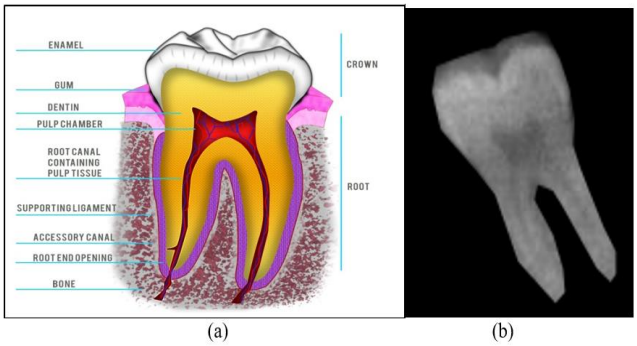
The user selects the tooth area. As shown in Figure 6, the click zones are marked with yellow circles. These sections can be adjusted later if needed. The chosen teeth are separated from the boundary regions.



(a) (b) (c)

Figure 6. (a) Freehand drawing (b) Zooming (c) Editing and saving.

Figure 7 shows the parts of the tooth (a) and the teeth created by removing the boundaries in the database (b).



(a) (b)

Figure 7. (a) Tooth sections (b) Drawing result.

The database creation process is recorded with the age, gender, number, and number of each tooth (AGE_GENDER_TOOTHNUMBER_COUNT.jpeg). As a result, for example, the 3nd tooth of 19 number for the males of 11 year old is saved as follows: 11_M_19_3. The tooth name of someone whose gender is female is kept as F instead of M. An example of this is shown in Figure 8, and a portion of this dataset appears.

0,10.5,F	0,10.5,F	0,10.5,F	0,10.5,F	0,10.5,F	0,10.5,F	0,10.5,F	0,10.5,F
1,10.5,M	1,10.5,M	1,10.5,M	1,10.5,M	1,10.5,M	1,10.5,M	1,10.5,M	1,10.5,M
2,10,F	2,10,F	2,10,F	2,10,F	2,10,F	2,10,F	2,10,F	2,10,F
3,10,M	3,10,M	3,10,M	3,10,M	3,10,M	3,10,M	3,10,M	3,10,M
4,11.5,F	4,11.5,F	4,11.5,F	4,11.5,F	4,11.5,F	4,11.5,F	4,11.5,F	4,11.5,F
5,11.5,M	5,11.5,M	5,11.5,M	5,11.5,M	5,11.5,M	5,11.5,M	5,11.5,M	5,11.5,M
6,11,F	6,11,F	6,11,F	6,11,F	6,11,F	6,11,F	6,11,F	6,11,F
7,11,M	7,11,M	7,11,M	7,11,M	7,11,M	7,11,M	7,11,M	7,11,M
8,12.5,F	8,12.5,F	8,12.5,F	8,12.5,F	8,12.5,F	8,12.5,F	8,12.5,F	8,12.5,F
9,12.5,M	9,12.5,M	9,12.5,M	9,12.5,M	9,12.5,M	9,12.5,M	9,12.5,M	9,12.5,M
10,12,F	10,12,F	10,12,F	10,12,F	10,12,F	10,12,F	10,12,F	10,12,F
11,12,M	11,12,M	11,12,M	11,12,M	11,12,M	11,12,M	11,12,M	11,12,M
12,13.5,F	12,13.5,F	12,13.5,F	12,13.5,F	12,13.5,F	12,13.5,F	12,13.5,F	12,13.5,F
13,13.5,M	13,13.5,M	13,13.5,M	13,13.5,M	13,13.5,M	13,13.5,M	13,13.5,M	13,13.5,M
14,13,F	14,13,F	14,13,F	14,13,F	14,13,F	14,13,F	14,13,F	14,13,F
15,13,M	15,13,M	15,13,M	15,13,M	15,13,M	15,13,M	15,13,M	15,13,M
16,14.5,F	16,14.5,F	16,14.5,F	16,14.5,F	16,14.5,F	16,14.5,F	16,14.5,F	16,14.5,F
17,14.5,M	17,14.5,M	17,14.5,M	17,14.5,M	17,14.5,M	17,14.5,M	17,14.5,M	17,14.5,M
18,14,F	18,14,F	18,14,F	18,14,F	18,14,F	18,14,F	18,14,F	18,14,F
19,14,M	19,14,M	19,14,M	19,14,M	19,14,M	19,14,M	19,14,M	19,14,M

Figure 8. Database view.

Figure 9 shows the number of teeth in the 4-21 age group. In addition, age, gender information of these teeth are also seen.

Age	Gender	Count	Age	Gender	Count	Age	Gender	Count
4	F	2	9.5	M	5	15.5	F	7
4	M	4	10	F	11	15.5	M	4
4.5	F	3	10	M	7	16	F	5
4.5	M	6	10.5	F	7	16	M	6
5	F	8	10.5	M	10	16.5	F	10
5	M	9	11	F	5	16.5	M	5
5.5	F	12	11	M	11	17	F	5
5.5	M	11	11.5	F	8	17	M	4
6	F	15	11.5	M	4	17.5	F	9
6	M	18	12	F	4	17.5	M	6
6.5	F	17	12	M	2	18	F	9
6.5	M	13	12.5	F	2	18	M	5
7	F	19	12.5	M	4	18.5	F	12
7	M	16	13	F	4	18.5	M	2
7.5	F	14	13	M	5	19	F	10
7.5	M	16	13.5	F	5	19	M	8
8	F	17	13.5	M	6	19.5	F	16
8	M	16	14	F	7	19.5	M	9
8.5	F	9	14	M	4	20	F	3
8.5	M	8	14.5	F	4	20	M	4
9	F	15	14.5	M	5	20.5	F	7
9	M	8	15	F	4	20.5	M	7
9.5	F	6	15	M	4	21	F	9

Figure 9. Age of 4-21 Dataset.

Figure 10 shows the number of teeth in the 21-63 age group.

Age	Gender	Count	Age	Gender	Count	Age	Gender	Count	Age	Gender	Count
21	M	8	28	M	12	35	M	7	42	M	2
21.5	F	13	28.5	F	11	35.5	F	5	42.5	F	9
21.5	M	7	28.5	M	7	35.5	M	3	42.5	M	10
22	F	7	29	F	5	36	F	12	43	F	2
22	M	8	29	M	11	36	M	5	43	M	3
22.5	F	12	29.5	F	15	36.5	F	10	43.5	F	8
22.5	M	13	29.5	M	7	36.5	M	9	43.5	M	8
23	F	6	30	F	5	37	F	7	44	F	2
23	M	5	30	M	3	37	M	2	44	M	3
23.5	F	10	30.5	F	7	37.5	F	11	44.5	F	5
23.5	M	5	30.5	M	11	37.5	M	6	44.5	M	5
24	F	11	31	F	6	38	F	6	45	M	3
24	M	7	31	M	6	38	M	7	45.5	F	8
24.5	F	8	31.5	F	6	38.5	F	7	45.5	M	4
24.5	M	7	31.5	M	10	38.5	M	9	46	F	10
25	F	5	32	F	5	39	F	4	46	M	5
25	M	7	32	M	6	39	M	3	47	F	9
25.5	F	11	32.5	F	9	39.5	F	6	47	M	7
25.5	M	8	32.5	M	10	39.5	M	9	48	F	9
26	F	6	33	F	6	40	F	6	49	M	5
26	M	8	33	M	4	40	M	6	50	M	5
26.5	F	7	33.5	F	5	40.5	F	4	51	M	7
26.5	M	11	33.5	M	9	40.5	M	3	52	F	5
27	F	13	34	F	3	41	F	7	52	M	7
27	M	4	34	M	6	41	M	4	57	M	5
27.5	F	7	34.5	F	4	41.5	F	5	60	M	5
27.5	M	6	34.5	M	10	41.5	M	7	63	M	5
28	F	8	35	F	5	42	F	3	-	-	-

Figure 10. Age of 21-63 Dataset.

2.3 Developed Method for Rotation

Teeth are automatically corrected for more accurate and standard results. The tooth rotation algorithm was developed as new and original.

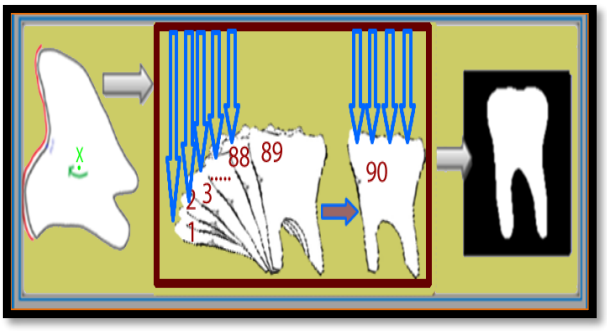


Figure 11. Tooth rotating.

In Figure 11, the tooth is rotated 180 degrees and the rotation is stopped when the total value on the Y axis during rotation is the smallest because the tooth is then in the most upright

position. In Figure 12, Algorithm-1 checks whether the tooth is in the correct position (perpendicular).

Algorithm-1: Fix Position

```
0:function private int fixPosition()
1:inputs: angle, result, tmpImage, calcTop.
2:outputs: angle.
3: Angle ← 0
4: Result ← int.MaxValue
5: tmpImage ← (Bitmap)this.imgTooth.Clone()
6:      for i = 1 to i <= 90 do
7:         calcTop ← calcPosValue(tmpImage)
8:          if (calcTop < result) then
9:             angle ← -i
10:            result ← calcTop
11:         end if
12:       tmpImage ← rotate(tmpImage, -1)
13:       new OtsuThreshold().ApplyInPlace(tmpImage)
14:     end for
15:imgTooth ← rotate(this.imgTooth, angle)
16:new OtsuThreshold().ApplyInPlace(this.imgTooth)
17: return angle
18:end function
```

Figure 12. Fix Position.

In Figure 13, Algorithm-2 is a sub-method of Algorithm-1 and controls the rotation process of the tooth.

Algorithm-2: Calculate Position Value

```
0:function private int calcPosValue(Bitmap img)
1:inputs: result, blobCounter, blobs, topEdge, bottomEdge.
2:outputs: angle.
3:      result ← 0
4:      blobCounter ← new BlobCounter()
5:      blobCounter.ProcessImage(img)
6:      blobs ← blobCounter.GetObjects(img, false)
7:      if (blobs.Length =1) then
8:        topEdge ← new List<IntPoint>()
9:        bottomEdge ← new List<IntPoint>()
10: blobCounter.GetBlobsTopAndBottomEdges(blobs[0], out topEdge, out bottomEdge)
11:         for i = 0 to i < topEdge.Count do
12:           result ← + topEdge[i].Y
13:         end for
14:       result ← / topEdge.Count
15:       result ← + topEdge.Count
16:     end if
17:  return result
18:end function
```

Figure 13. Calculate Position Value.

As a result of this process the database is prepared and can be used for the desired study. Figure 14 shows a section from the database of 7-7.5 years old rotated tooth image.

Figure 14. A section from the database.

3 DISCUSSION

Dental images of the same age and gender group of 37,5_F_18_1 and 37,5_F_18_2 may differ as shown in Figure 15. This could be in any group of teeth. If the database is prepared in this way, then some test methods may have a higher error rate. Such images should not be added to the database.

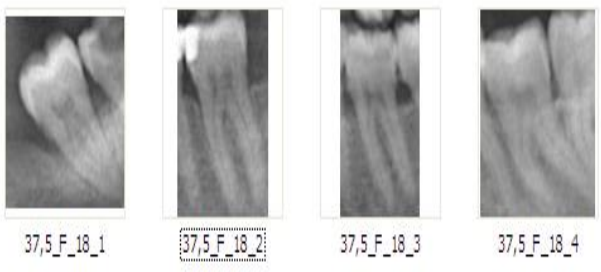


Figure 15. The same age but different looking teeth.

In real life, the size of people according to age can differ from theoretically. Morphological characteristics of the teeth in some dental groups etc. the information may be the same. In practice, such data may be encountered.

The group (A) shown in Figure 16 is generally in the small age group. Since the pulp is not completely closed at this age, it should be included in the tooth. Incorrect boundary removal (B) causes incorrect calculations. The result should be like (C) after the correct border extraction.

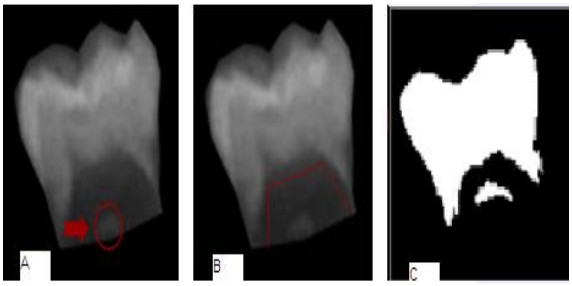


Figure 16. Preventing incorrect drawings.

In dentistry a mirror of a tooth has the same characteristics as itself. The teeth in the database in our study have the same properties as the mirror because they are rotated. Thus, the number of images in the dental database can be considered as 2630 images. The example mirror teeth shown in Figure 17 are shown.

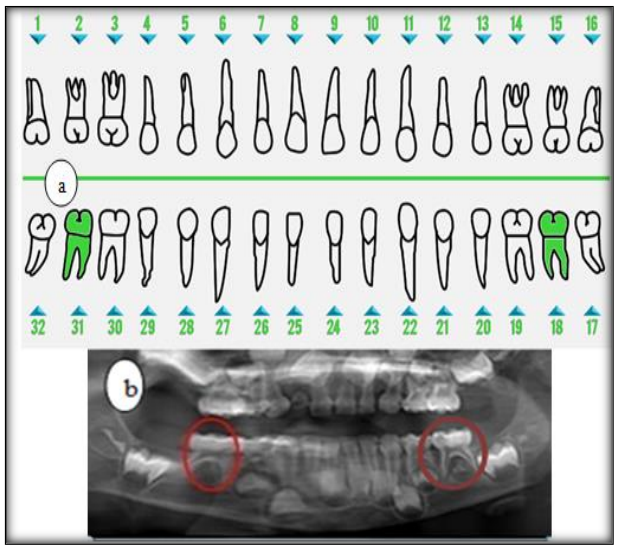


Figure 17. Mirror teeth.

If the image of the teeth in the database has an upright appearance, the application gives more accurate results. Even on images taken from the same x-ray machine, the density may be different. For this reason, this effect was tried to be eliminated by using pre-process methods in this study. This study presents an example of how to create a dataset. The preprocesses suggested in this study are only suggestions. Different preprocesses can be applied and datasets of different sizes can be created.

4 CONCLUSION AND SUGGESTIONS

In this study, a database was created by using x-ray images, using image processing methods, to perform age determination process and to be used in different fields. First,

panoramic x-ray images were obtained. In these images, 1313 (2626 teeth with a mirror) boundary image was removed and added to the database. The images were first preprocessed so that each image was kept to a certain standard of appearance. After preprocesses, images were corrected in the plane with a novel and originally developed rotation algorithm. The created database can be used to process fields such as classification, recognition, image processing. In future studies, these images can be subjected to some pre-processing and age and gender estimates can be made by conducting experimental studies with deep learning models.

Conflict of Interest Statement

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The study is complied with research and publication ethics.

Artificial Intelligence (AI) Contribution Statement

This manuscript was entirely written, edited, analyzed, and prepared without the assistance of any artificial intelligence (AI) tools. All content, including text, data analysis, and figures, was solely generated by the authors.

Contributions of the Authors

Emre AVUÇLU: Conceptualization, Methodology, Software, Validation, Writing - review & editing, original draft.

Fatih BAŞÇİFTÇİ: Conceptualization, Methodology, Investigation, Writing - review.

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