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Three-Dimensional Determination (Morphometric Study) of Arch Perimeter and Palatal Depth in an Iraqi Sample Aged 17–25 Years with Sickle Cell Anemia: A Cross-Sectional Study

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Abstract
Sickle cell anemia (SCA) is a hereditary disorder caused by the substitution of valine for glutamic acid in position six of globin's beta chain. Segmental arch dimensions, arch perimeter, and palatal depth comparison between SCA and control using the three-dimensional (3D) technique was the aim of this study. This cross-sectional investigation was carried out in Karbala City. The sample consisted of 200 casts (100 SCA and 100 control). Each group consisted of 50 casts upper, and 50 casts lower (25 males and 25 females). The arch perimeter was calculated using two segmented arch lengths bilaterally. Palatal depth was measured from the mesiolingual cusp tip of the upper first permanent molar to the corresponding palatal vault. The difference between the control and SCA groups was calculated using the independent t-test. Except for lower left incisal to canine distance (LLI-C), where $p = 0.01$ there was no significant difference in segmental arch measurements and perimeter between males in SCA and males in control. There was no significant difference in segmental arch measurements and perimeter between females in SCA and females in control. There was no significant difference in palatal depth between the control and SCA (male and female). SCA did not affect the segmental, arch perimeter, and palatal depth measurements.

Introduction:

Sickle cell disease (SCD) is a group of hereditary hematologic diseases. At low oxygen tension, an abnormal kind of hemoglobin (hemoglobin S) polymerizes, giving red blood cells a sickle shape and decreasing their usual flexibility [1, 2]. The most prevalent kind of SCD is SCA, which, if untreated, can cause early childhood mortality. The majority of SCD patients and carriers are of African, Asian, Arabian, and Mediterranean descent [3], Orofacial symptoms in the form of mid-facial overgrowth [4], asymptomatic pulpal necrosis and gingival enlargement [5], and osteomyelitis of the mandible [6] have also been observed in SCD patients.

According to Gupta [7], children with SCD have distinctive facial features such as frontal bossing and maxillary projection, which lead to malocclusion, exposure of their teeth, and depression of the nasal bridge. Epidemiology data show that SCD patients are concentrated in two distinct geographic locations in Iraq, one among the Arab population in the extreme south and another among the Kurdish population in the extreme north, where they pose significant health issues [8]. Dental arch perimeter (or length) is an important orthodontic diagnosis factor [9]. It is essential that we must increase oral health awareness by lowering the prevalence of caries, which cause tooth loss and can affect dental arch circumference [10]. Several authors have employed a variety of techniques for determining the perimeter of the dental arch. One of these techniques is measuring these features directly by stretching a brass wire [11] or steel wire [12], straightening it, and then determining the wire's length. Rotation, crowding, and/or displacement of teeth are examples of dental abnormalities that affect this technique. It is also less accurate, particularly for identifying the line of occlusion, due to differences in geometric shape and arch length, and hence requires substantial assessment regarding the appropriate arch form [13]. Another method is to divide the dental arch into four [14] or six [15] segments, with the sum of these measurements considered as the dental arch perimeter. The segmented arch method is widely accepted as a simple, exact, and practical method for determining the perimeter of the dental arch [16]. In modern orthodontics, digital 3D orthodontic models are a significant replacement for older models for a variety of diagnostic criteria [17].

Naoumova, et al. made digital measurements on a 3D model of the dental casts by using special software using the segmented arch technique [18]. Because of its morphology and position, the palate is a crucial anatomical component in determining the type of skeletal pattern, and more importantly, the palate can be influenced by orthodontic therapy [19]. There are several studies regarding palatal height assessment; however, the majority have concentrated on craniofacial disorders, Johnson and Baghdady [20] found that individuals with Turner's condition had deeper palatal depth.

From the literature review, there was no previous study concerning arch perimeter and palatal depth in patients with SCA so the purpose of this study:

1- Segmental arch dimension and arch perimeter comparison between SCA (male and female) and control group.

2-palatal depth comparison between SCA (male and female) and control.

The null hypothesis claimed that there is no significant difference between SCA and control in arch perimeter and palatal depth.

Materials and Methods

The ethical committee of the College of Dentistry at the University of Baghdad approved the study protocol (Ref No.592, Apr. 2022). A morphometric study was carried out from April 2022 to August 2022. The sample for this study consisted of 200 casts (100 SCA and 100 control), and each group consisted of 50 casts upper, and 50 casts lower (25 males and 25 females). The SCA group was taken from Karbala teaching hospital for Children as this hospital receives all patients with SCA with different ages from infants to older patients. The control group was taken from Karbala University and Karbala specialized center. The age range was 17-25 years old for the SCA and control groups. The selection criteria for the SCA group were:

- The participants were SCA patients; this was proven by a laboratory and a medical examination in addition to their medical history.
- They were Iraqi Arabic.
- They had completely permanent dentition, excluding the third molar.
- They possessed teeth with Class I (molar and canine) relationship.
- Their teeth were devoid of localized components that jeopardize the integrity of dental arches, such as congenitally absent, retained deciduous, and extra teeth.
- They had normally shaped teeth, no heavy fillings, and no history of facial surgery, orthopedic, or orthodontic treatment.
- They had no history of poor oral habits like thumb sucking or mouth breathing.

The criteria used for the control group were the same criteria used for the SCA group except for the following:

• The subjects were healthy and had no disease of genetic origin.

Upper and lower dental stone (Durguix, Spain) casts were digitized for each participant using a dental scanner (Dof Corp., Edge, South Korea) and according to the manufacturer's guidelines. They were saved as files in the Standard Triangle Language (STL) format. We assessed the dental arch measures using a laptop (Intel Core i5, 250+GBs SSD Disk, Windows 10, 64 bit) and a dedicated 3D planning software SolidWorks® 2020 (Dassault systemes SolidWorks Corp., Waltham, Massachusetts, USA). The program allowed for varied movements of the digital cast, allowing users to visualize the precise placements of landmarks. Measurements were done according to the method described by Naoumova, et al [18].

Arch perimeter (Antero-posterior study):

The sum of two-segmented arch length bilaterally. The first half is from the distal measurement point of the first molar and the canine's mesial contact point, while the second half is from the lateral incisor's distal contact point and the central incisor's mesial contact point Fig. (1) [18, 21].

Palatal depth (Vertical study): The vertical distance from a point at the line joining the mesiolingual cusp tip of the first permanent molar to the corresponding palatal vault in the midline Fig. (2) [18, 22].

Statistical analysis: For the statistical analysis, the Statistical Package for Social Sciences for Windows, version 26.0 (SPSS Inc. Chicago, IL, USA) was used. The data were described using mean, standard deviation, maximum, and minimum values. For 12 study models, intra-examiner (examined two times with a four-week break) and inter-examiner calibration using intraclass correlation coefficient (ICC) were employed to assess measurement reliability. The inferential statistic was done using Independent-samples t-test for the comparison between**:**

- Between SCA and control (males and females) for segmental arch dimensions and perimeter.
- Palatal depth between SCA (male and female) and control.
- Between SCA male and female for all dimensions**.**

The statistical significance level was set at ($P<0.05$).

Results

According to the descriptive statistics in table (1), all dimensions were greater in SCA males than control except for LRI-C was higher in the control. There was no statistically significant difference except for LLI-C where the difference was highly significant where a p-value of 0.01. In table (2), the mean value for ULC-M1, ULI-C, URI-C, and UPPER PERIMETER were higher in control than SCA females while URC-M1, LLC-M1, LLI-C, LRC-M1, LRI-C, and LOWER PERIMETER were higher in SCA female than control. There was no significant difference between the two groups. When comparing males to females in table (3) all variables were higher in males than females except for LLC-M1 and LRC-M1 were higher in the female group with no significant difference between the two groups. When comparing palatal depth between SCA and control (male and female), the mean value was lower in the SCA group than control with no significant difference as in Fig. (3).

Discussion

SCD is a group of inherited blood illnesses in which sickle hemoglobin (HbS) causes structural abnormalities in erythrocytes. HbS is distinguished by a replacement of valine for glutamic acid in the sixth position of the globulin chain [23]. SCA, the most prevalent and harmful form of SCD, is caused by the genetic inheritance of both parents' HbS genes (SS genotype) [24]. The sample was taken according to the medical records taken from Karbala teaching hospital for Children. The majority of the sample was from Ein-Altamr in Karbala City. This is a tribal district of Karbala City with very high rates of endogamy. The goal of every comprehensive orthodontic treatment is to obtain optimal, esthetic harmony, functional efficiency, and structural balance [25, 26]. The dental arch perimeter is one of the most important diagnostic devices before starting any orthodontic treatment [27]. Various authors have used different approaches to determine the perimeter of the dental arch. Profit claims that computer analysis takes less time [28]. Heredity is proposed as a key etiological factor in malocclusions in which palatal dimensions are involved and it is recommended that the right orthodontic or orthopedic procedures be used at a young age to lessen or eliminate unfavorable genetic influences on palatal breadth, depth, and length [19]. There are several studies regarding palatal height assessment, however, the majority have concentrated on craniofacial disorders, Johnson and Baghdady [20] found that individuals with Turner's condition had deeper palatal depth. Skrinjarić et al. [29] in a study showed that patients with Down's syndrome when compared to those from a control population, had palate lower in depth. Considering the results of our investigation did not approach statistical significance in terms of arch perimeter and palatal depth between SCA and control groups, there was insufficient evidence to reject the null hypothesis. When comparing segmental arch dimensions between males in the SCA group and control group in table (1) there was no significant difference except for LLI-C which was highly significant but not of clinical significance as the mean difference of about 0.67 which is of a small amount for clinical significance. There was no significant difference when comparing segmental arch dimensions and perimeter between females in SCA and the control group. This means that those adult patients have grown normally because observable growth retardation occurs by 2 years of age, affecting weight more than height and with no evident gender difference [30]. By adulthood, normal height is achieved, but the weight stays lower than that of controls. Nutritional supplementation has been shown to restore normal growth [31]. SCA is a disease whose clinical manifestations are influenced by a variety of genetic and environmental factors, including dietary and socioeconomic factors [32]. In addition to advancements in SCD treatment, patients today are fundamentally different from those in the past. Modern medicine is allowing people with SCD to live longer [33]. In table (3), all the dimensions were higher in males than females with SCA except for LLC-M1, and this might be explained by females' smaller alveolar processes and bony ridges [34]. Average female muscular weakness, males have a longer growing period than females. From the palatal depth comparison between SCA and control, the mean value was smaller in the SCA group (male and female) than the control group but not statistically significant as in Fig. (3), and this disagrees with Jacobson and Bandeen [35], who found that SCD causes the palatal plane to steepen progressively with age, especially in adolescence, but he did not know the process. This study had some limitations including the COVID-19 pandemic's interference with sample collection and the general health of the patients, which made it difficult to get their impressions, particularly during times of crisis.

Conclusion

From the results of our study, we concluded that measurements of the segmental arch's dimensions, perimeter, and palatal depth were unaffected by SCA and that dimensions were higher in males than females due to variations in the growth period and muscular force.

List of abbreviations: ULC-M1: upper left canine to first molar**, ULI-C:** upper left incisal to canine distance**, URC-M1:** upper right canine to first molar**, URI-C:** upper right incisal to canine distance**, LLC-M1:** lower left canine to first molar**, LLI-C:** lower left incisal to canine**, LRC-M1:** lower right canine to first molar**, LRI-C:** lower right incisal to canine**.**

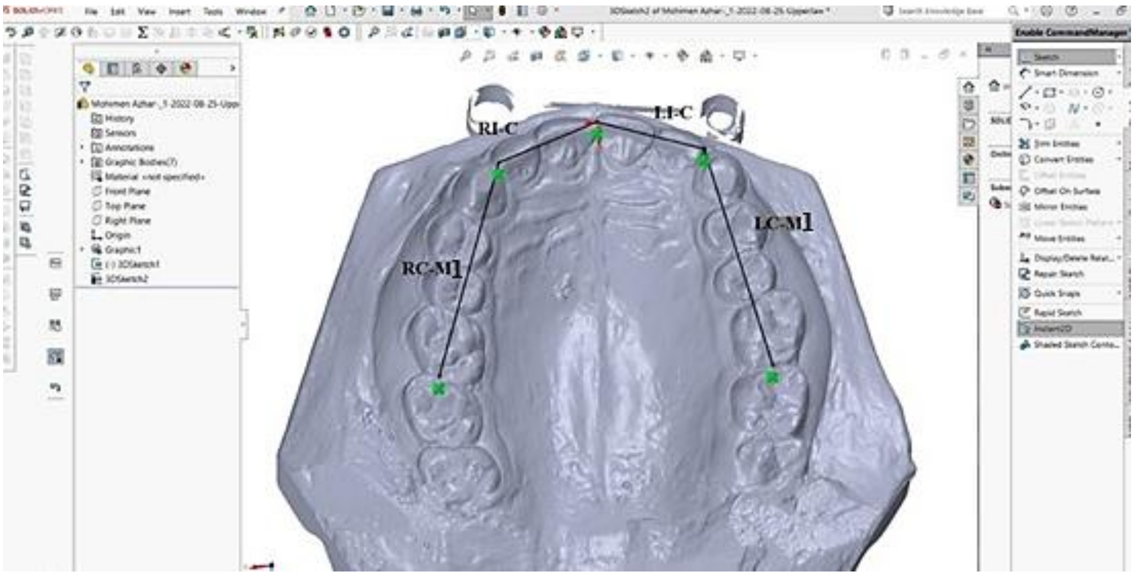

Fig. (1): Arch perimeter determination: sum of two bilateral arch lengths\: **RC-M1**: Right canine to first molar, **RI-C**: Right incisal to canine, **LI-C**: left incisal to canine, **LC-M1**: Left canine to first molar.

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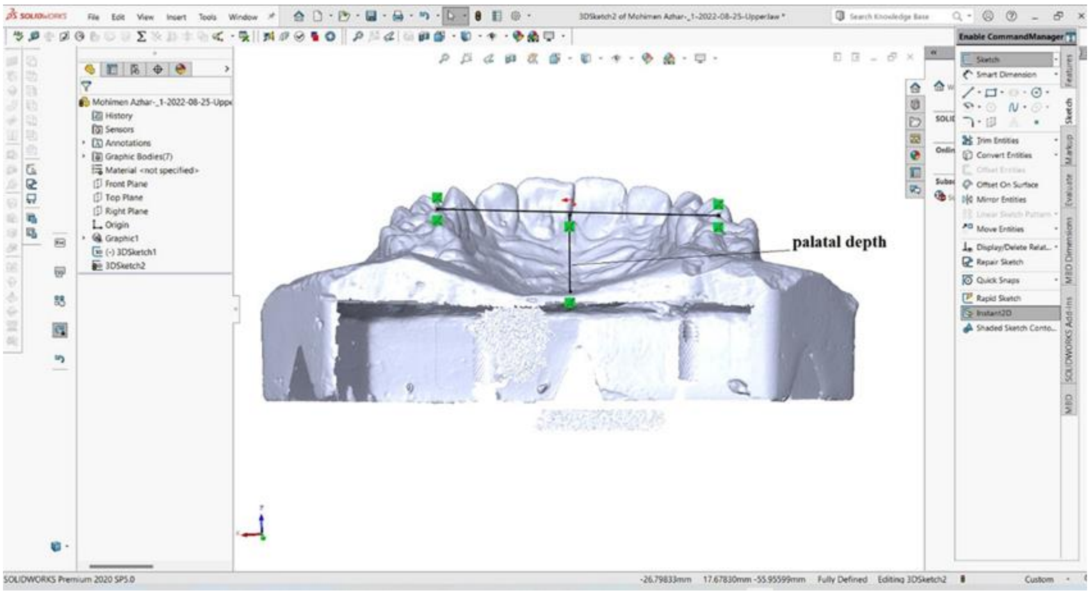

Fig. (2): palatal depth determination.

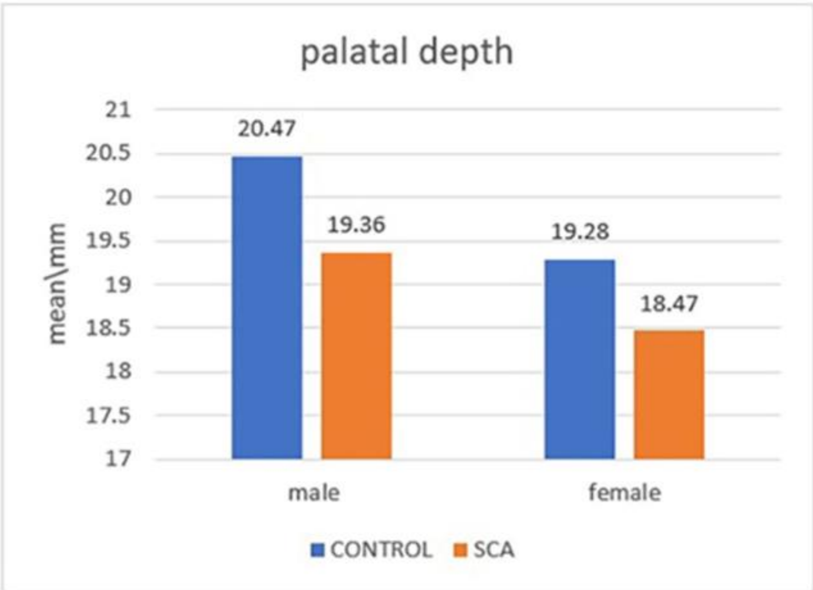

Fig. (3): A graph showing palatal depth comparison between SCA (male and female) and control.

Table (1): descriptive statistics and segmental dental arches dimensions comparison in SCA and control males (independent sample- t- test).

VARIABLES	Male group	MEAN	SD	MINI	MAXI	Mean difference	T-test	P VALUE
ULC-M1	Control	32.76	1.4	28.8	39.72	-0.37	0.76	0.45
	SCA	33.13	1.98	30.41	36.18			
ULI-C	Control	15.38	1.43	13.61	17.58	-0.34	0.95	0.35
	SCA	15. 72	1.01	13.27	20.55			
URC-M1	Control	32.95	1.6	30.03	37.94	-0.49	1.04	0.3
	SCA	33.44	1.69	29.7	36.38			
URI-C	Control	15.46	1.54	13.2	17.6	-0.12	0.32	0.75
	SCA	15.58	1.19	13.82	21.76			
UPPER PERIMETER	Control	96.55	5.17	89.94	114.24	-1.31	0.92	0.36
	SCA	97.86	4.86	85.63	110.19			
LLC-M1	Control	32.04	1.82	28.89	36.76	-0.21	0.39	0.7
	SCA	32.25	1.91	28.85	37.84			
LLI-C	Control	11.16	0.68	10.17	13.28	-0.67	2.87	0.01**
	SCA	11.83	0.96	9.55	12.59			
LRC-M1	Control	32.07	1.93	27.53	36.8	-0.08	0.14	0.89
	SCA	32.15	2.00	28.90	38.55			
LRI-C	Control	11.68	3.47	8.64	14.62	0.05	-0.07	0.95
	SCA	11.63	1.23	9.30	27.99			
LOWER PERIMETER	Control	86.95	4.77	75.89	97.24	-0.91	0.68	0.5
	SCA	87.86	4.65	78.93	100.50			

Nonsignificant difference P>0.05, **highly significant P≤0.01, **ULC-M**1: upper left canine to first molar, **ULI-C**: upper left incisal to canine, **URC-M**1: upper right canine to first molar, **URI-C**: upper right incisal to canine, **LLC-M**1: lower left canine to first molar, **LLI-C**: lower left incisal to canine, **LRC-M1:** lower right canine to first molar**, LRI-C:** lower right incisal to canine**, P -VALUE:** probability value, **SD**-standard deviation; **mini**-minimum; **maxi**-maximum.

Table (2): descriptive statistics and Segmental dental arches dimensions comparison between sickle cell anemia and control female (independent sample- t- test).

VARIABLES	FEMALE group	MEAN	SD	MINI	MAXI	Mean difference	T-test	P VALUE
ULC-M1	Control	32.81	1.49	29.35	34.83	- 0.21	0.48	0.63
	SCA	33.02	1.66	30.02	36.67			
ULI-C	Control	15.66	1.64	12.76	21.93	0.23	-0.6	0.55
	SCA	15.43	0.97	13.59	17.03			
URC-M1	Control	32.91	1.64	12.76	21.93	-0.41	0.76	0.45
	SCA	33.32	1.99	29.54	37.91			
URI-C1	Control	15.63	1.87	12.68	22.57	0.56	-1.26	0.21
	SCA	15.07	1.18	12.89	17.88			
UPPER PERIMETER	Control	97.01	5.01	83.4	107.01	0.17	-0.13	0.9
	SCA	96.84	4.36	87.77	104.77			
LLC-M1	Control	31.79	1.62	28.05	34.72	-0.02	0.04	0.97
	SCA	31.81	1.73	28.46	35.01			
LLI-C	Control	11.13	0.9	9.94	13.43	-0.31	1.2	0.23
	SCA	11.44	0.9	10.1	13.57			
LRC-M1	Control	31.58	1.76	27.36	35.46	-0.34	0.71	0.48
	SCA	31.92	1.56	29.32	34.89			
LRI-C	Control	11.23	0.78	9.74	12.99	-0.12	0.60	0.55
	SCA	11.35	0.65	10.08	13.19			
LOWER PERIMETER	Control	85.74	4.24	75.2	93.05	-0.78	0.67	0.51
	SCA	86.52	4.1	78.92	94.39			

Nonsignificant difference P>0.05, **ULC-MD**: upper left canine to molar distance, **ULI-CD**: upper left incisal to canine distance, **URC-MD**: upper right canine to molar distance, **URI-CD**: upper right incisal to canine distance, **LLC-MD**: lower left canine to molar distance, **LLI-CD**: lower left incisal to canine distance, **LRC-MD:** lower right canine to molar distance**, LRI-CD:** lower right incisal to canine distance**, P**- VALUE: probability value, **SD**-standard deviation; **mini**-minimum; **maxi**-maximum.

Table (3): descriptive statistics and Segmental dental arches dimensions comparison between SCA male and female (independent sample- t- test).

VARIABLES	GENDER	MEAN	SD	Mean difference	T- test	P VALUE
ULC-M1	**SCA MALE**	33.13	1.98	0.11	0.20	0.84
	SCA FEMALE	33.02	1.66			
ULI-C	**SCA MALE**	15.72	1.01	0.29	1.01	0.32
	SCA FEMALE	15.43	0.97			
URC-M1	**SCA MALE**	33.44	1.69	0.12	0.23	0.82
	SCA FEMALE	33.32	1.99			
URI-C	**SCA MALE**	15.58	1.19	0.51	1.53	0.13
	SCA FEMALE	15.07	1.18			
UPPER PERIMETER	**SCA MALE**	97.86	4.86	1.02	0.78	0.44
	SCA FEMALE	96.84	4.36			
LLC-M1	**SCA MALE**	32.25	1.91	0.44	0.85	0.40
	SCA FEMALE	31.81	1.73			
LLI-C	**SCA MALE**	11.83	0.96	0.39	1.46	0.15
	SCA FEMALE	11.44	0.94			
LRC-M1	**SCA MALE**	32.15	2.00	0.23	0.45	0.65
	SCA FEMALE	31.92	1.56			
LRI-C	**SCA MALE**	11.63	1.23	0.28	1.00	0.32
	SCA FEMALE	11.35	0.65			
LOWER PERIMETER	**SCA MALE**	87.86	4.65	1.34	1.08	0.29
	SCA FEMALE	86.52	4.10			

Nonsignificant difference P>0.05, **ULC-M**1: upper left canine to first molar, **ULI-C**: upper left incisal to canine, **URC-M**1: upper right canine to first molar, **URI-C**: upper right incisal to canine, **LLC-MD**: lower left canine to first molar, **LLI-C**: lower left incisal to canine, **LRC-M1:** lower right canine to first molar**, LRI-C:** lower right incisal to canine, **P VALUE:** probability value**, SD**-standard deviation**; mini**-minimum**; maxi**-maximum**.**

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