Original Article

Malocclusion and Craniofacial Characteristics in Saudi Adolescents with Sickle Cell Disease

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Abstract

Background: Sickle cell disease can result in dentofacial abnormalities. However, in Saudi Arabia, there are limited data with respect to orthodontic manifestations in patients with sickle cell disease.

Objective: To determine the malocclusion and craniofacial characteristics in sickle cell disease adolescents and compare them with that of controls from the Eastern Province of Saudi Arabia.

Methods: This comparative cross-sectional study included 112 Saudi patients with sickle cell disease, aged 12–18 years, and 124 age-matched Saudi controls from three major hospitals in Al Khobar and Dammam, Saudi Arabia. The Dental Aesthetic Index was used to assess malocclusion and orthodontic treatment needs. Digital lateral cephalometric radiographs were recorded for each patient and control, and its analysis included linear and angular measurements.

Results: The prevalence of malocclusion was 87.5% in sickle cell disease patients and 54% in controls ($P = 0.0001$). The percentage of sickle cell disease patients with severe malocclusion that required orthodontic treatment was higher than that of controls (37.5% vs. 26.6%). In the sickle cell disease cohort, incisal segment crowding (72.4%), overjet (67.3%) and maxillary misalignment in the anterior segment (56%) were the most prevalent types of malocclusions and were significantly higher than that of controls ($P < 0.05$). About 38% and 67% of the sickle cell disease patients had openbite and posterior crossbite, respectively, compared with 19.3% ($P = 0.001$) and 37.1% ($P = 0.0001$) of controls, respectively. Cephalometric analysis showed that SNA (86.7°) and ANB (9.9°) angles were significantly higher in sickle cell disease patients than in controls (81.5° and 2°, respectively). In addition, lower central incisor-to-Frankfort horizontal plane (55°) and interincisal angles (121.5°) were significantly lower in sickle cell disease patients than in controls.

Conclusion: Adolescents with sickle cell disease had a higher prevalence of malocclusion and greater orthodontic treatment needs than controls. Similarly, they had greater incisal crowding, overjet, openbite and posterior crossbite and demonstrated higher SNA, ANB and lower interincisal angles than controls. The findings of this study suggest that adolescents with sickle cell disease should be provided frequent dental examinations and early orthodontic treatment to improve their oral health, and thus quality of life.

Keywords: Adolescents, craniofacial, malocclusion, Saudi, sickle cell disease

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INTRODUCTION

Sickle cell disease (SCD) is a common genetic abnormality that affects about 20–25 million people worldwide, with 300,000 new cases being diagnosed every year.[1,2] Sickle cell anemia (SCA) is the most common and severe form of SCD.[3] Frequent painful crises, episodes of acute chest syndrome, symptomatic osteonecrosis, priapism, overt stroke, persistent splenomegaly and gallstones are some of the clinical conditions common among SCA patients.[4] SCD results in poor health-related quality of life, and the same has also been reported among Saudi adolescents with SCD.[5] In Saudi Arabia, SCD is widely distributed, but is most prevalent in the Eastern Province, and the SCA patients of this region primarily have the milder Arab–Indian (AI) haplotype.[5-7]

Reduced oxygen supply to oral tissues can cause osteomyelitis of the jaw. This, in turn, leads to neuropathic changes in the mental nerve and results in numbness of areas supplied by this nerve such as the chin and lower lip.[3] Oral manifestations of SCD include delayed tooth eruption, pallor of oral mucosa, orofacial pain and increased susceptibility to oral infections.[8,9] In addition, hypercementosis, development of pulpal stones, necrosis of pulp as well as enamel and dentine hypomineralization can occur.[3,10] In SCD, the craniofacial complex can undergo abnormal changes including oxycephaly, a large trabecular bone pattern and protrusion of jaws, and these changes can lead to skeletal and dental malocclusions, thereby compromising patients' psychosocial behavior and esthetics.[4] Several dentofacial abnormalities have been reported in African SCA patients, including opacity of the teeth, malocclusion, delayed tooth eruption, developmental problems of enamel and dentine, calcification of pulp and greater maxillary incisor proclination.[11-14]

In terms of prevalence and types of malocclusions in SCD patients, in Nigeria, the prevalence of malocclusion has been reported in 88.5% of SCA patients, with 48.2% having increased overjet.[15] Another study from Nigeria observed that 35% of SCD patients, compared with 16.6% of controls, had increased overbite and overjet.[11] In Brazil, a study found that all the 36 SCD adolescent patients analyzed had malocclusion.[16] In a retrospective study of SCD patients, 56% were reported to have increased overjet in the United States.[17] Further, cephalometric analysis has shown that maxillary incisor proclination is significantly higher among SCD patients than among controls.[12]

Despite the high prevalence of SCD in Saudi Arabia, limited data are available about the craniofacial anomalies, including malocclusion, among Saudi SCD patients. The objective of the study was to determine the prevalence of malocclusion, orthodontic treatment needs and craniofacial characteristics in SCD adolescents and compare them with that of non-SCD adolescents from Al Khobar and Dammam, Saudi Arabia.

METHODS

This comparative cross-sectional study included 112 SCD Saudi patients aged 12–18 years attending the SCD clinics at King Fahd Hospital of the University, Al Khobar, and at Dammam Central Hospital and Al-Qatif Central Hospital, Dammam, between October 2012 and November 2013. This study included adolescents because they tend to exhibit changes in bone that affect their facial profile.[3] SCD clinics diagnosed patients based on hematological, molecular and genetic tests. Subsequently, 124 age-matched, Saudi, non-SCD controls were recruited from the surgical outpatient and pediatric clinics of these hospitals. A convenience sampling technique was used for recruiting the study participants.

Exclusion criteria included current, or a history of, orthodontic or orthopedic treatment that involved facial surgery (orthognathic or plastic), carriers of a congenital syndrome or craniofacial abnormality and/or SCD patients who were fully edentulous. SCD patients in crisis and those with no genotype records were also excluded from the study. An informed consent form was sent to the parents or guardians, and adolescents whose parent/guardian provided a signed consent were included in the study. The study was also conducted in accordance with the Declaration of Helsinki, 2013. Ethical approval for this study was obtained from the Institutional Review Board (#2017-2-206) of Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia.

Each participant provided demographic data including age, gender and parents' education. Subsequently, each participant underwent intraoral clinical examinations and radiographic assessments. The Dental Aesthetic Index (DAI) was used to assess the severity of malocclusion and orthodontic treatment needs of the study participants.[18] Ten components of DAI that broadly evaluate dentition, spacing and occlusion were assessed.[16] The World Health Organization guidelines for oral examination were followed during data collection.[19] Clinical examination was conducted using community periodontal probe, a mirror, gloves, a wooden spatula, cotton gauze and artificial light. Calibration of the examiner was carried out on a sample of 20 patients by an experienced orthodontist

(gold standard) who was an expert in using DAI ($\kappa > 80$). About 15 participants were reexamined by the examiner to ensure intraexaminer reliability. Moreover, the severity of malocclusion was also assessed by evaluating posterior openbite, posterior crossbite and overbite,[20] as DAI does not cover these occlusal traits.[21]

Standardized digital lateral cephalometric radiographs were recorded for each patient and control. Cephalometric radiographs were obtained using X-ray Kodak 8000c (Care Stream Health, Rochester, NY, USA). Furthermore, to ensure consistency, the machine was positioned at an identical height and distance from each patient. The films were traced using acetate paper by the examiner. Cephalometric analysis included linear and angular measurements that were performed twice to reduce errors. Intraexaminer reliability was evaluated twice within 2 months.[12]

Statistical analysis was conducted using the SPSS software (version 22; IBM SPSS Statistics for Windows, Armonk, NY, USA). Means and standard deviations were calculated for quantitative variables, and percentages were calculated for qualitative variables. Comparisons were made between SCD patients and controls using Pearson's chi-square test and Student's *t*-test. $P < 0.05$ was considered statistically significant.

RESULTS

The mean age of the SCD patients was 15.6 ± 1.7 years, while the mean age of the controls was 16.2 ± 1.9 years. In the SCD patient group, 54.5% ($n = 61$) were males, whereas in the control group, 58.9% ($n = 73$) were females [Table 1]. The results indicate that 34.8% of SCD patients presented with canine Class II, 41% with increased overjet, 15.2% with deep overbite and 67% with posterior crossbite. On the other hand, 27.4% of the control group had canine Class II, 22.5% had increased overjet, 16.1% had deep overbite and 37.1% had posterior crossbite. About 38.4% ($n = 43$) of the SCD patients had openbite compared with 19.3% ($n = 24$) of controls ($P = 0.001$) [Table 2].

Table 3 shows that 37.5% of SCD patients had severe malocclusion (DAI: 31–35) that required orthodontic treatment and 12.5% had very severe or disabling malocclusion that required mandatory orthodontic treatment. However, in the control group, only 26.6% had severe malocclusion and 6.5% had very severe or disabling malocclusion. According to the DAI criteria, more SCD patients (72.4%) had incisal crowding than controls (56.7%). Overjet was found in 67.3% of SCD patients and in 32.8% of controls. Similarly, a greater percentage of SCD patients exhibited maxillary and mandibular misalignment than controls [Table 4].

The results in Table 5 indicate that the SNA (86.7°) and ANB (9.9°) angles in SCD patients were significantly higher than the angles in the control group (81.5° and 2°, respectively). Lower central incisor-to-Frankfort horizontal (FH) plane (55°) and interincisal (121.5°) angles were significantly lower in SCD patients than that in controls. The ratio of posterior facial height to anterior facial height was significantly lower in SCD patients (60.4%) than that in controls (66.8%). In addition, the SNB (76.8°), SNPog (76.4°), facial angle (81.2°) and angle of convexity (11.4°) in SCD patients were significantly lower than that in controls. Furthermore, the nasolabial angle was significantly smaller in SCD patients (80.5°) than in controls (95.6°). Figure 1 shows a cephalometric radiograph of an SCD patient with maxillary protrusion.

DISCUSSION

Oral manifestation of SCD can result in several changes and abnormalities.[3,4,8-10] However, little is known about the orthodontic manifestations in Saudi SCD patients. In Saudi

Table 1: Gender and parents' education level of the study participants

Variables	SCD patients ($n = 112$), *n* (%)	Non-SCD controls ($n = 124$), *n* (%)
Gender		
Male	61 (54.5)	51 (41.1)
Female	51 (45.5)	73 (58.9)
Parents' education level		
College degree	27 (24)	55 (44.4)
High school education	47 (42)	46 (37.1)
Primary school education	38 (34)	23 (18.5)

SCD – Sickle cell disease

Table 2: Malocclusion among sickle cell disease patients and non-sickle cell disease controls

Variables	SCD patients ($n = 112$), *n* (%)	Non-SCD controls ($n = 124$), *n* (%)	*P*
Malocclusion	98 (87.5)	67 (54)	<0.0001*
Canine classification			
Class I	73 (65.2)	90 (72.6)	0.243
Class II	39 (34.8)	34 (27.4)	
Overjet			
Normal	66 (59)	96 (77.5)	0.003*
Increased	46 (41)	28 (22.5)	0.001*
Overbite			
Normal	28 (25)	51 (41.1)	0.009*
Deep	17 (15.2)	20 (16.1)	0.832
Reduced	24 (21.4)	29 (23.4)	0.711
Openbite	43 (38.4)	24 (19.3)	0.001*
Posterior crossbite			
Present	75 (67)	46 (37.1)	<0.0001*
Absent	37 (33)	78 (62.9)	

*Statistically significant. SCD – Sickle cell disease

Table 3: Dental Aesthetic Index results of the study participants

DAI classification	SCD patients (*n* = 112), *n* (%)	Non-SCD controls (*n* = 124), *n* (%)	*P*
No abnormality or mild malocclusion (DAI ≤25) (no or slight treatment need)	22 (19.6)	46 (37.1)	0.002*
Definite malocclusion (26–30) (treatment elective)	34 (30.4)	37 (29.8)	0.867
Severe malocclusion (31–35) (treatment highly desirable)	42 (37.5)	33 (26.6)	0.068
Very severe or disabling malocclusion (≥36) (treatment mandatory)	14 (12.5)	8 (6.5)	<0.0001*

*Statistically significant. DAI – Dental Aesthetic Index; SCD – Sickle cell disease

Table 4: Criteria of the Dental Aesthetic Index

Variable	SCD patients, *n* (%)	Non-SCD controls, *n* (%)	*P*
Malocclusion			
Yes	98 (87.5)	67 (54)	<0.0001*
No	14 (12.5)	57 (46)	
Number of missing teeth			
None	68 (69.4)	58 (86.6)	0.001*
One tooth	19 (19.4)	7 (10.4)	0.051
Two to six teeth	11 (11.2)	2 (3)	0.015*
Incisal segment crowding			
Present	71 (72.4)	38 (56.7)	0.016*
Absent	27 (27.5)	29 (43.3)	
Incisal segment spacing			
Present	28 (28.6)	30 (44.8)	0.011*
Absent	70 (71.4)	37 (55.2)	
Diastema			
Present	21 (21.4)	12 (17.9)	0.561
Absent	77 (78.6)	55 (82.1)	
Maxillary misalignment			
Present	55 (56)	20 (30)	<0.0001*
Absent	43 (44)	47 (70)	
Mandibular misalignment			
Present	45 (45.9)	21 (31.3)	0.017*
Absent	53 (54.1)	46 (68.7)	
Overjet			
Present	66 (67.3)	22 (32.8)	<0.0001*
Absent	32 (32.7)	45 (67.2)	
Anterior openbite			
Present	42 (42.9)	14 (20.9)	0.0003*
Absent	56 (57.1)	53 (79.1)	
Anteroposterior molar condition			
Normal	34 (34.7)	26 (38.8)	0.525
Half cusp	26 (26.5)	25 (37.3)	0.069
Entire cusp	38 (38.8)	16 (23.9)	0.013*

*Statistically significant. SCD – Sickle cell disease

Arabia, SCD is most prevalent in the Eastern Province.[6,7] Accordingly, this study provides valuable information about malocclusion, orthodontic treatment needs and craniofacial characteristics of patients with SCD in the Eastern Province of Saudi Arabia.

Using DAI, the present study found high prevalence (87.5%) of malocclusion in the SCD cohort. This finding is in line with that of Costa *et al*.[10] and Alves e Luna *et al*.,[16] who, also using DAI, reported that 76.3% of SCA and ~100% of SCD patients, respectively, had malocclusion. In addition, similar to our study, Costa *et al*.[10] found that SCA patients have higher orthodontic treatment needs than controls. In Brazil, Costa *et al*.[10] reported that 30% of SCA patients had very severe or disabling

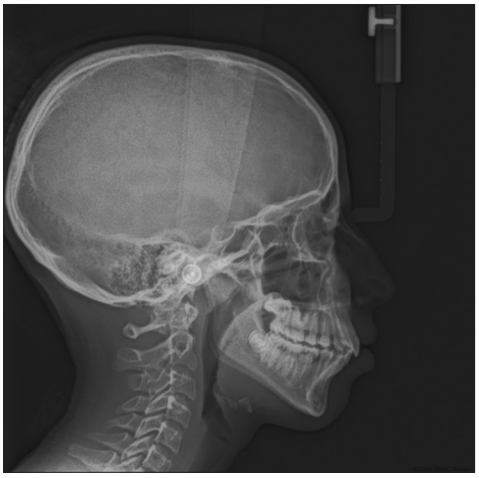

Figure 1: Cephalometric radiograph of a patient with sickle cell disease

malocclusion, whereas Alves e Luna *et al*.[16] found that 80.6% of SCD adolescents presented with very severe or disabling malocclusion. In Nigeria, Onyeaso and da Costa[22] reported that 50% of SCD patients had very severe or disabling malocclusion. The high prevalence of malocclusion among SCD patients could be due to skeletal changes in jaws, orofacial muscular imbalance and lack of proper lip seal.[11]

In the present SCD cohort, incisal segment crowding (72.4%), overjet (67.3%) and maxillary misalignment in the anterior segment (56.0%) were the most prevalent types of malocclusions and were significantly higher than that in controls. The expansion of bone marrow to compensate for premature breakdown of red blood cells and reduced oxygen supply results in higher prevalence of malocclusion in SCD patients than that in healthy individuals.[16] Costa *et al*.[10] found mandibular misalignment in the anterior segment to be the most prevalent malocclusion (86%) in SCA patients followed by incisal segment crowding (79.6%), maxillary misalignment (68.8%) and overjet (67.7%). Surprisingly, they reported that mandibular and maxillary misalignments were more pronounced in controls than that in SCA patients. Other studies found lower prevalence of different types of malocclusion in patients with SCD. For example, Okafor *et al*.,[11] daCosta *et al*.[15] and Taylor *et al*.[17] found that 35%, 48.2% and 30% of SCD patients, respectively, had overjet malocclusion. The prevalence of

Table 5: Comparison of cephalometric measurements of the study participants

Measurements	SCD patients (n = 112)		Non-SCD controls (n = 124)		t
	Mean	SD	Mean	SD	
SNA (°)	86.7	3.5	81.5	2.8	2.8*
SNB (°)	76.8	3.8	79.5	2.5	2.1*
ANB (°)	9.9	3.2	2	1.8	3.1*
SNPg (°)	76.4	3.8	81.2	3.2	2.3*
Facial angle (FH-NPog) (°)	81.2	4.1	87.3	3.1	2.2*
Angle of convexity (N-A-Pog) (°)	11.4	2.1	4.1	1.4	2.4*
Gonial angle (°)	130.5	3.7	124.6	3.3	1.7
Cranial base angle (°)	136.8	4.2	132.2	3.4	1.6
SN to Mand. Pl. (°)	35.7	3.1	32.4	2.4	1.5
SN to Pal Pl. (°)	11.6	1.8	9.8	1.2	1.4
Pal. Pl. to Mand. Pl. (°)	25.8	2.5	23.4	1.8	1.1
FH Pl. to Mand. Pl. (°)	30	3.6	25	2.3	1.2
S-G/N-Me (%)	60.4	4.2	66.8	2.9	2.1*
ANS-Me/N-Me (%)	58.7	3.7	55.5	2.4	1.8
A B to Occl. Pl. (wits) (mm)	+5.5	2.4	−1/0	1.2	2.3*
1 to 1 (°)	121.5	4.3	130.7	3.2	3.1*
1 to Mand. Pl. (°)	95	4.8	90	3.9	2.4*
1 to FH Pl. (°)	55	3.7	65	2.6	2.9*
1 to N-B angle (°)	27.8	2.3	25.4	1.8	1.8
1 to N-B mm (°)	5.5	2.4	4.5	1.4	1.3
1 to N-A angle (°)	25.7	2.6	22.3	1.6	1.2
1 to N-A (mm)	6.5	2.3	4.5	1.4	1.3
1 to FH Pl.	118.8	4.7	112.3	3.5	2.3*
UL-E plane	+2.5	2.1	−4.5	1.5	1.8
LL-E plane	+1.6	1.4	−2.2	1.1	1.7
NL angle (°)	80.5	3.8	95.6	3.2	3.6*

*Statistically significant. SCD – Sickle cell disease; SD – Standard deviation

openbite in the SCD patients of the current study was higher than that in an African cohort.[11]

In the present study, the ANB angle, which represents the anteroposterior relationship between the maxilla and the mandible, was significantly higher in SCD patients than in the control group. Higher ANB angle is associated with maxillary projection among SCD patients. This corroborates with the results of Pithon *et al*.,[23] who observed increased ANB angle in SCD patients. Collectively, this suggests that in SCD patients, there is a tendency toward Class II malocclusion. In the present study, a larger SNA angle was observed among SCD adolescents than controls. The SNA angle represents the anteroposterior positioning of the maxilla in relation to the cranial base, and an increased angle would result in a prognathic maxilla. However, our findings are in contrast with that of Licciardello *et al*.,[12] who found no significant differences in the ANB and SNA angles in Sicilian SCD patients and controls. Similarly, Maia *et al*.[24] diagnosed SCD patients with proper positioning of the maxilla with reference to the cranial base because their SNA angle average was 84.56°, thereby showing no compensatory maxillary expansion. Our study found that lower central incisor-to-FH plane (55.0°) and interincisal (121.5°) angles were significantly lower in SCD patients than that in controls. These findings corroborate the results of Shnorhokian *et al*.,[25] who observed maxillary protrusion and forward mandibular growth in SCD children with retrusion of maxillary and mandibular incisors. Similar findings were reported among African-Americans by Altemus and Epps.[26] The differences in craniofacial features in different populations could be explained by the type of SCD found in different parts of the world, in addition to genetic variations and environmental influences such as dietary and socioeconomic factors.[12]

In the present study, the prevalence of malocclusion, orthodontic treatment needs and craniofacial traits was reported in SCD adolescents and compared with the control group. Therefore, this comparative study has greater strength than a similar descriptive study without a control group.[6] In addition, the study used a large sample size, and clinical recordings were measured by a calibrated examiner using standardized procedures. However, due to the limited availability of SCD patients, a convenience sampling technique was used, which has limitations such as improper representation of subgroups of different sociodemographic origins.[27]

CONCLUSION

The study found that SCD patients had a higher prevalence of malocclusion and greater orthodontic treatment needs than controls. Malocclusions such as incisal crowding, overjet, openbite and posterior crossbite were more pronounced in SCD adolescents than in controls. Similarly, SCD patients had higher SNA and ANB angles and lower interincisal angle than controls. Given the high prevalence of malocclusion and the orthodontic treatment needs due to systemic complications of SCD, it is recommended that patients with SCD should be provided with frequent dental examinations and early orthodontic treatment. These measures will help prevent malocclusion, and thus improve the quality of life of SCD patients.

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Conflicts of interest

There are no conflicts of interest.

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