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The association between sickle cell disease and dental caries in African Americans

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Abstract

This study sought to determine whether there was an association between sickle cell disease (SCD) and dental caries in African-American adults. A sample of 102 African-American adult patients with SCD from Washington, D.C., and Baltimore, Maryland, were matched to 103 African-American adult subjects, who did not have SCD. The match was by age, gender and recruitment location. Each subject underwent a standardized oral examination as well as an interview to ascertain risk factors for dental caries. For individuals with incomes of less than \$15,000, subjects with SCD had more decayed (10.36 versus 1.58) and fewer filled (2.86 versus 8.45) surfaces compared to subjects without SCD with both differences being statistically significant ($p < 0.05$) after adjusting for age and gender. The results suggest that low-income African Americans with SCD may be at increased risk for dental caries and are less likely to receive treatment with a restoration.

Keywords

sickle cell disease; dental caries; retrospective studies; teeth; risk factors

Introduction

Although the effects of sickle cell disease (SCD) on general morbidity and mortality have been studied extensively,¹⁻⁴ relatively little research has been done on the possible consequences of SCD on dental health. SCD is a term used to describe the symptomatic genetic blood disorders associated with the replacement of normal hemoglobin with abnormal hemoglobin

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S (HbS) and does not usually include individuals who are heterozygous for the condition, usually referred to as sickle cell trait. These symptomatic disorders include sickle cell anemia (SCA), sickle-hemoglobin C disease (SC) and sickle-beta thalassemia (S β thal).⁷ SCD is most prevalent among African Americans, with sickle cell anemia and sickle-hemoglobin C disease being the most common types. When the erythrocytes that contain sickle cell hemoglobin are exposed to hypoxic conditions, they assume a more rigid shape, making it more difficult for them to pass through small blood vessels. This leads to a reduction in blood flow and occlusion of the microvasculature with tissue necrosis. When this occurs, it is referred to as a sickle cell crisis and is characterized by severe pain, peaking after three or four days but usually lasting for about seven days. In conjunction with the painful crisis episodes, focal areas of infarction often develop in various organs with debilitating results.³⁻⁶

The literature has very few studies of the relationship between SCD and oral health. Comparatively speaking, three oral pain,⁷⁻⁹ two periodontal,¹⁰⁻¹¹ and two dental caries^{9, 12} studies constitute the bulk of the research on this relationship. In one of the oral pain studies,⁷ dental caries was one of the outcomes measured so in fact there have been three studies^{7,9, 12} looking at dental caries and its association with SCD excluding the pilot study previously conducted by this research group.¹³ The three oral pain articles⁷⁻⁹ all reinforce the same theme: do not initially treat oral pain symptoms with extractions without properly diagnosing the situation as patients with SCD reported a higher frequency of undiagnosed oral pain episodes compared to patients without SCD. The two periodontal studies^{10,11} concluded that individuals with SCD do not appear to be at increased risk for periodontal disease although one study¹⁰ only included adults while the other¹¹ only included adolescents.

In 1986, one study¹² looked at dental caries in 37 patients with SCA aged 14 to 33 years matched for age and sex to 24 patients without SCD in a Nigerian hospital. A reduced prevalence of caries was found among individuals with SCA. However, no description was given of how dental caries were measured nor were statistical comparisons presented. The authors did not clearly define whether the outcome measure — the presence of dental caries — referred to untreated caries or the total DMFS score. In a second study⁹ published in 1998, 51 patients with SCD were compared to 51 siblings without SCD and their parents in Jamaica (aged 13 to 45 years). No statistically significant differences were found in the prevalence or severity of caries between subjects with SCD and those without SCD as measured by the DMFT index and its component scores.

In 2002, our research group compared 35 dental patients with SCA, aged 6 years and older, to 140 dental patients who did not have anemia (in a 4:1 age-,gender-matched study) to determine whether individuals with SCA had a higher prevalence of dental caries, as measured using the DMFS index.¹³ All subjects were self-identified either as persons of African descent or African Americans. While there was little difference in mean DMFS scores between subjects with and without SCA who were children and adolescents, the mean DMFS for subjects aged 18 and older was 29% higher in the group with SCA. In addition, the mean number of missing tooth surfaces for all subjects with SCA was 41% higher than the subjects without SCA. As these findings were based on data abstracted from existing dental records, no information was available on risk factors for dental caries to control for other confounding factors.

The aim of this study was to determine if there was an association between persons with SCD and DMFS scores using a cohort of adult African-American subjects with SCD and comparing them to a cohort of adult African-American subjects who did not have SCD while controlling for risk factors for dental caries.

Methods

Study design and subject identification

In this retrospective cohort study, a cohort of subjects with and without SCD were recruited from two locations: Washington, D.C., and Baltimore, Md. Patients with SCD who were admitted to Howard University Hospital in Washington, D.C., or who attended the outpatient hematology clinic at Howard University Hospital, were invited to participate; similarly, patients with SCD who attended the outpatient hematology clinic at Johns Hopkins Hospital in Baltimore were recruited. Admitted patients with SCD who expressed an interest in study participation after seeing the recruitment flyer or speaking to the hematology resident or attending physician were approached. Eligible patients were African-American adults 18 years and older who had been diagnosed with SCD and who attended either of the two hospitals between September 2002 and July 2003.

Subjects who did not have SCD were recruited among new and existing adult African-American patients who attended Howard University College of Dentistry in Washington, D.C., or the Advanced General Dentistry Clinic of the University of Maryland Dental School in Baltimore, and who were seeking or currently receiving treatment at the dental schools. The Advanced General Dentistry Clinic is not a specialty clinic and provides comprehensive dental care for the general population of the city of Baltimore. Subjects without SCD within each city were selected in equal numbers to the subjects with SCD and individually matched by age (± 5 years), gender, and recruitment location. Subjects without SCD were only excluded if they had a self-reported history of SCD or sickle cell trait. Study subjects were given \$50 as compensation toward travel costs. The study received Internal Review Board approval from all participating institutions and written informed consent was obtained from all study subjects.

Data collection

Dental examination

Dental caries were measured using the DMFS Index. Dental examinations were conducted either at the patient's bedside at Howard Hospital, in an available room during either of the two outpatient hematology sessions, or in a dental operatory at one of the two dental schools under the same standardized format for subjects with and without SCD. All dental examinations were conducted using mouth mirrors and explorers, but no radiographs were made. For patient examined at bedside or in the outpatient hematology clinics, a portable dental light was used. Three examiners performed all dental examinations to assess the caries status of teeth. Teeth lost due to trauma or orthodontic treatment based on the patient's self-reported reasons for tooth loss were excluded. Prior to data collection, the three dental examiners were calibrated according to National Institute of Dental and Craniofacial Research (NIDCR) criteria for the diagnosis and recognition of coronal caries over a three-day calibration period by a trained and experienced reference examiner.¹⁴ The kappa coefficients for both inter-examiner and intra-examiner reliability indicated high levels of agreement. The average inter-examiner kappa was 0.96 while the average intra-examiner kappa was 0.90.

Sickle cell disease severity

The clinical severity of SCD was measured by asking how many sickle cell crisis episodes requiring hospital visits or hospital admissions occurred within the last 12 months. Annual frequency of sickle cell crisis episodes is an accepted estimate of clinical severity and has been used in previous studies.^{15,16} Since hydroxyurea medication is prescribed to decrease crisis frequency in those with recurring episodes, its use was included in the measure of severity.¹⁷ Therefore, severity was classified into the following three groups: *low severity* — zero hospital admissions or emergency room visits for sickle cell crisis within the last 12 months

and no current use of hydroxyurea; *medium severity* — one or two hospital admissions or emergency room visits for sickle cell crisis within the last 12 months and no current use of hydroxyurea; *high severity* — three or more hospital admissions or emergency room visits for sickle cell crisis within the last 12 months or current use of hydroxyurea.

Risk factors for caries

Interviewers were calibrated in a training session that provided an introduction to a questionnaire. Interviewers used a questionnaire to obtain information on exposure to known risk factors for dental caries including socioeconomic status, age, gender, access to dental care, toothbrushing frequency and diet (consumption of sugar or sweetened baked goods).¹⁸⁻²³

Statistical analysis

The distribution of risk factors for caries among subjects with SCD from Baltimore and Washington, D.C., were initially analyzed independently. The data were then pooled once it had been determined that there were no statistically significant or clinically important differences. This same two-step analytical process was also done with subjects who did not have SCD. The association between SCD status and dental caries was evaluated by means of least-squares regression in order to allow for the calculation of unadjusted and adjusted ($\pm$ standard error of the mean) mean values for the caries outcomes. Covariates that were associated with both SCD status and the caries outcome at a significance level of 0.2 or less were included in the final models and age was included as a continuous variable in all multivariate models. Correlations between covariates were examined using Pearson's correlation coefficient. Given the large number of missing values for the household income variable and its relatively high correlation with employment status (-0.425 , $p < 0.001$), employment status was used as a measure of socioeconomic status in the adjusted models instead of household income. The exception was in analysis stratified by income level, where household income was used as a marker for socioeconomic status for those reporting a value for household income. Statistical tests were two sided, and p values of 0.05 or less were considered statistically significant. Statistical analyses were performed using Stata 8 software (STATA Corporation, College Station, Texas).

Results

Of the 102 subjects with SCD who were recruited, 79.4% had sickle cell anemia (SCA), 15.6% had sickle-hemoglobin C disease and 5.0% had sickle-beta thalassemia. It was found that 71.6% had a high clinical severity of SCD, 14.7% had a medium rating, and 13.7% were of low clinical severity. One hundred and three age-, gender- and residence-matched subjects who did not have SCD were recruited. Demographic characteristics of the study subjects are shown in Table 1. As expected, there were no statistically significant differences between the persons with and without SCD, with regard to age distribution, gender or recruitment location since they were individually matched on these characteristics. Subjects with SCD who responded to the household income question were nearly three times more likely (50% versus 17.6%) to have indicated household incomes of less than \$15,000. These persons were also more likely to be unemployed or receiving disability, to have lower levels of education and to have not been to a dentist within the last year. There were no statistically or clinically significant differences in the frequency of consumption of sweet snacks or toothbrushing frequency between the two groups (data not shown).

Table 2 shows the mean unadjusted and adjusted values for the DMFS and their component scores for the study subjects. In unadjusted analyses, there were statistically significant differences between the mean values for the number of decayed and filled surfaces but not for the overall DMFS count. The subjects with SCD had 3.6 times more decayed surfaces, and

less than half the number of filled surfaces of the subjects who did not have SCD, with both differences being statistically significant. In the adjusted analysis, the same directional trends were evident but only the differences in the mean values for the number of filled surfaces remained statistically significant.

In the analysis stratified by income level (Table 3), for those with incomes of less than \$15,000 subjects with SCD had six times as many decayed surfaces as those without SCD after adjusting for age and gender. Subjects without SCD also had three times more filled surfaces compared to subjects with SCD after adjusting for age and gender, both outcomes being statistically significant. For those with incomes between \$15,000 and \$34,999, no association was observed between SCD status and caries outcomes, although for those with incomes of \$35,000 or more, subjects with SCD had significantly fewer filled surfaces (8.62 versus 16.62, $p<0.01$) even after adjusting for age and gender (data not shown).

When the multivariate analysis adjusted for age and gender was repeated for those with incomes of less than \$15,000 according to SCD severity, subjects with SCD classified as high severity ($n=31$) had almost nine times more decayed surfaces compared to subjects without SCD ($n=15$) (12.54 versus 1.45) and less than half the number of filled surfaces (3.53 versus 8.43), both differences were statistically significant, $p<0.05$ (data not shown).

Discussion

This is the first study to evaluate the effect of SCD on dental caries while accounting for caries risk factors. The results indicate that for low-income African Americans, those with SCD are significantly more likely to have more decayed and fewer filled teeth. As the DMFS index is composed of one untreated category (D) and two treated categories (M and F), the data from this study provides evidence that low-income subjects with SCD are getting dental caries but are not receiving appropriate treatment, i.e. restorations, even when compared to an income-matched control group of subjects who do not have SCD. Clearly two alternative, non-mutually exclusive hypotheses could be contributing to these observations; 1) a patient-centered hypothesis in which low-income persons with SCD may defer dental treatment leading to increased D with lower F and M surfaces because they place a higher priority on other aspects of health care besides oral health; and 2) a dentist-centered hypothesis, in which dentists may be more reluctant to provide treatment (e.g., restorations) due to fear of post-operative complications with patients who have SCD. Given the sparse literature on the oral health of persons with SCD, the latter hypothesis needs to be explored in future studies. There may be psychosocial factors associated with African Americans having SCD that lead these individuals to place less value on oral health than African Americans without SCD; also, persons with lower incomes may find seeking dental care too much of a burden. Future studies should be designed to understand the role that patient-centered psychosocial factors play in determining oral health outcomes in patients with SCD, and to understand the comfort level and clinical decision-making pathways of dentists who treat patients with SCD.

There were some limitations to the present study. The selection of the subjects who did not have SCD from a group seeking dental treatment, a behavior which is related to one of the outcome measures, creates an obvious selection bias. As this was an initial investigation, the selection of the control group was dictated by funding realities that put constraints on selection. Ideally, a control group whose subjects did not have SCD should have been selected from the same community as the subjects with SCD to be similar in sociodemographic characteristics. The control group was selected from subjects seeking and receiving dental treatment and so may have had better dental health with fewer decayed and more filled surfaces than a control group selected from the same community as the subjects with SCD. Thus the results from this

study may be biased with larger differences being observed between the two groups. In future studies conducted by this research group, this methodological concern will be addressed.

Another problem was the fact that examiners were not blinded to SCD status when carrying out the dental examinations and so could have introduced “examiner bias.” However, the examiners were calibrated and the field data collection phase was short; also, the clinical criteria of the F and M were clearly defined, so this bias is not likely to have distorted the DMFS data. Some of the patients with more severe SCD were unwilling to participate due to the discomfort of their SCD symptoms and, as a result, the true differences between the groups may be even larger than observed in this study. In addition, radiographs were not used for the diagnosis of dental caries. However, any misclassification that would be introduced as a result of not using radiographs would be non-differential and reduce any differences observed between the two groups closer to the null value. Finally, the small number of subjects limited the ability to perform stratified analysis by income and should be interpreted accordingly. Future studies should seek to reproduce these findings using larger sample sizes.

Interestingly, the demographic data in Table 1 suggest that for African Americans, having SCD may be associated with low incomes and limited educational and employment opportunities. For those with the most clinically severe forms of SCD, frequent sickle cell crisis episodes could lead to absenteeism from school or work. The subjects with SCD were recruited from hospitals with 71.6% of those recruited having high clinical severity; this demographic data may be an indicator of the economic hardship that SCD causes for those persons with the most clinically severe disease.

Conclusions

The results of the study suggest that low-income African Americans with SCD may be at increased risk for dental caries and were less likely to receive treatment with a restoration compared to low-income African Americans without SCD even after adjusting for the traditional risk factors for dental caries.

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References

1. Gladwin MT, Sachdev V, Jison ML, et al. Pulmonary hypertension as a risk factor for death in patients with sickle cell disease. *N Engl J Med* 2004;350(9):886–95. [PubMed: 14985486]
2. Siddiqui AK, Ahmed S. Pulmonary manifestations of sickle cell disease. *Postgrad Med J* Jul;2003 79 (933):384–90. [PubMed: 12897216]
3. Prasad R, Hasan S, Castro O, Perlin E, Kim K. Long-term outcomes in patients with sickle cell disease and frequent vaso-occlusive crises. *Am J Med Sci* Mar;2003 325(3):107–9. [PubMed: 12640284]
4. Platt OS, Brambilla DJ, Rosse WP, et al. Mortality in sickle cell disease. Life expectancy and risk factors for early death. *N Engl J Med* 1994;330(23):1639–44. [PubMed: 7993409]
5. Mankad, V.; Moore, R. *Sickle Cell Disease: Pathophysiology, Diagnosis, and Management*. Praeger Publishers; 1992.
6. Sanger RB, McTigue DJ. Sickle cell anemia — its pathology and management. *J Dent Handicap* 1978;3:9–21. [PubMed: 376564]
7. Cox GM. A study of oral pain experience in sickle cell patients. *Oral Surg Oral Med Oral Path* 1984;58:39–41. [PubMed: 6589576]
8. O'Rourke CA, Micropoulos C. Orofacial pain in patients with sickle cell disease. *Br Dent J* 1990;169:130–2. [PubMed: 2206667]

9. O'Rourke CA, Hawley GM. Sickle cell disorder and orofacial pain in Jamaican patients. *Br Dent J* 1998;185:90–2. [PubMed: 9718806]
10. Crawford JM. Periodontal disease in sickle cell disease subjects. *J Periodontol* 1988;59(3):164–9. [PubMed: 3162981]
11. Arowojolu MO. Periodontal probing depths of adolescent sickle cell anemic (SCA) Nigerians. *J Periodont Res* 1999;34:62–4. [PubMed: 10086888]
12. Okafor LA, Nonnoo DC, Ojehanon PI, Aikhionbare O. Oral and dental complications of sickle cell disease in Nigerians. *Angiology* Sept;1986 37(9):672–5. [PubMed: 3767074]
13. Laurence BE, Reid BC, Katz RV. Sickle cell anemia and dental caries: A literature review and pilot study. *Spec Care Dentist* 2002;22(2):70–4. [PubMed: 12109598]
14. U.S. Department of Health and Human Services. Oral Health Surveys of the National Institute of Dental Research Diagnostic Criteria and Procedures. January;1991 NIH Publication No. 91-2870
15. Westerman MP, Bailey K, Freels S, Schlegel R, Williamson P. Assessment of painful episode frequency in sickle-cell disease. *Am J Hematol* Mar;1997 54(3):183–8. [PubMed: 9067495]
16. Platt OS, Thorington BD, Brambilla DJ, et al. Pain in sickle cell disease. Rates and risk factors. *N Engl J Med* 1991;325:11–6. [PubMed: 1710777]
17. Charache S, Terrin MI, Moore RD, et al. Effect of hydroxyurea on the frequency of painful crises in sickle cell anemia. *N Engl J Med* 1995;332:1317–22. [PubMed: 7715639]
18. Mascarenhas AK. Oral hygiene as a risk indicator of enamel and dentin caries. *Community Dent Oral Epidemiol* 1998;26:331–9. [PubMed: 9792125]
19. Kleemola-Kujala E, Rasanen L. Relationship of oral hygiene and sugar consumption to risk of caries in children. *Community Dent. Oral Epidemiol* 1982;10:224–33. [PubMed: 6958405]
20. Dominguez-Rojas V, Aslasio-Arbiza P, Orrega-Molina P, Gordillo-Florencio E, Garcia-Nunez JA, Bascones-Martinez A. Analysis of several risk factors involved in dental caries through multiple logistic regression. *Int Dent J* 1993;43(2):149–56. [PubMed: 8320009]
21. Garcia-Closas R, Garcia-Closas M, Serra-Majem L. A cross-sectional study of dental caries, intake of confectionary and foods rich in starch and sugars, and salivary counts of *Streptococcus mutans* in children in Spain. *Am J Clin Nutr* 1997;66:1257–63. [PubMed: 9356546]
22. Powell LV. Caries prediction: a review of the literature. *Community Dent Oral Epidemiol* 1998;26:361–71. [PubMed: 9870535]
23. Drake CW, Beck JD, Lawrence HP, Koch GG. Three-year coronal caries incidence and risk factors in North Carolina elderly. *Caries Res* 1997;31:1–7. [PubMed: 8955986]

Table 1
Selected characteristics of subjects with sickle cell disease (SCD) and control group without SCD.

Characteristics	Sickle Cell Disease		Non-Sickle Cell Disease		P value
	Number of subjects	%	Number of subjects	%	
Age (years)					
18-29	39	38.2	39	37.9	0.97
30-39	29	28.4	27	26.2	
40-49	22	21.6	23	22.3	
50-59	9	8.8	11	10.7	
60-70	3	2.9	3	2.9	
Recruitment location					
Washington, D.C.	71	69.6	72	69.9	0.96
Baltimore	31	30.4	31	30.1	
Gender					
Female	57	55.9	57	55.3	0.94
Male	45	44.1	45	44.7	
Education					
≤ High school	50	49.0	24	23.3	<0.001
> High school	52	51.0	79	76.7	
Household income*					
Less than \$15,000	40	50.0	15	17.6	<0.001
\$15,000 to \$34,999	16	20.0	34	40.0	
\$35,000 to more	24	30.0	36	42.4	
Employment status					
Employed, student or retired	45	44.1	96	93.2	<0.001
Homemaker	10	9.8	2	1.9	
Unemployed or on disability	47	46.1	5	4.9	
Time since last dental visit					
Within the last year	52	51.0	90	87.4	<0.001
More than 1 year ago	50	49.0	13	12.6	
Frequency of toothbrushing*					
2 or more times a day	57	57.0	71	68.9	0.09
Once a day	38	38.0	31	30.1	
Not every day	5	5.0	1	1.0	
Total	102	%	103	%	

P values derived from *chi*-square tests of homogeneity.

* 22 SCD and 18 non-SCD subjects missing values for income, 2 SCD subjects missing values for toothbrushing frequency.

Table 2
Mean decayed, missing, filled surfaces (DMFS) indices and component scores for SCD and non-SCD subjects.

Covariate	Unadjusted means			Adjusted means		
	SCD (n=102)	Non-SCD (non=103)	P value	SCD (n=102)	Non-SCD (n=103)	p value
Decayed surfaces (D)	8.11 (0.89)	2.25 (0.88)	<0.001	5.99 (1.01)	4.33 (1.00)	0.293
Missing surfaces (M)	15.73 (1.79)	11.29 (1.78)	NS	13.51 (1.98)	13.49 (1.96)	NS
Filled surfaces (F)	5.43 (0.91)	13.55 (0.90)	<0.001	6.67 (1.03)	12.34 (1.02)	<0.001
DMFS	29.18 (1.22)	27.11 (1.22)	NS	28.01 (1.35)	28.26 (1.34)	NS

SCD=Sickle cell disease.

NS= Not statistically significant.

Standard error in parentheses.

The adjusted models contained age, employment status and time since the last dental visit for the number of decayed and filled surfaces.

The adjusted models contained age and employment status for the number of missing surfaces and the overall DMFS score.

Table 3
Mean decayed, missing, filled surfaces (DMFS) indices and component scores for SCD and non-SCD subjects with incomes of less than \$15,000.

Covariate	Unadjusted means			Adjusted means		
	SCD (n=40)	Non-SCD (n=15)	p value	SCD (n=40)	Non-SCD (n=15)	p value
Decayed surfaces (D)	10.35 (1.93)	1.60 (3.15)	<0.05	10.36 (1.94)	1.58 (3.18)	<0.05
Missing surfaces (M)	19.77 (3.84)	13.80 (6.27)	NS	18.63 (3.86)	16.85 (6.34)	NS
Filled surfaces (F)	2.98 (0.75)	8.13 (1.23)	<0.01	2.86 (0.75)	8.45 (1.24)	<0.01
DMFS	33.10 (4.31)	23.53 (7.04)	NS	31.85 (4.33)	26.87 (7.12)	NS

SCD=Sickle Cell Disease.

NS= Not Statistically significant.

Standard error in parentheses.

The adjusted models contained age and gender for all the caries outcomes.