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Bone Changes in the Mandible: A Radiographic Study of a Paediatric Population with SS Sickle Cell Disease in Senegal

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Abstract

Introduction: Sickle cell disease is a genetic disorder in which one of the musculoskeletal manifestations is osteonecrosis, which preferentially affects the femoral head. However, damage to the mandibular bone has been reported in the literature. This study aimed to investigate bone changes in the mandible of children with SS sickle cell disease. **Method:** A case-control study was conducted on 100 children aged 5 to 15 years. Cases were children with SS sickle cell disease and controls were children without sickle cell disease. Bone changes were studied using radiographic variables: radiographic zones, decorticalisation of the mandibular canal, and mandibular cortical index. The Chi^2 and Fisher tests were used to compare the distribution of the variables of interest between the groups. **Results:** The study population was made up of 55% boys and the mean age was 10.01 ± 2.86 years. There was a significant difference in the distribution of the presence of a radiolucent area of the mandibular body ($p < 0.001$) between the groups (46% versus 2%) and of the apex ($p < 0.001$) between the groups (54% versus 4%). In addition, almost 1/3 of the children (28%) had a radio-opaque area at the apex (25% versus 3%) and one child in 10 in the sickle cell group had a radio-opaque area of the mandibular body. The distribution of the presence of decortication of the mandibular canal was significantly different ($p < 0.001$) between cases (54%) and controls (6%). **Conclusion:** The study revealed significant radiographic bone changes in children with sickle cell disease. Thus, dental radiography may be a diagnostic tool of choice for sickle cell disease in children.

Keywords

Radiographic Bone Changes, Mandible, Sickle Cell Disease, Child

1. Introduction

Sickle cell disease is an inherited hemoglobin disorder characterized by chronic hemolytic anemia, increased susceptibility to infection, damage to vital organs, and intermittent episodes of vascular occlusion, causing both acute and chronic pain [1]. According to the WHO, almost 5% of the world's population carries a gene responsible for a hemoglobin anomaly [2]. The majority of people with this disease live in black Africa, with prevalence rates ranging from 10% to 40% [3]. It poses a major public health problem in developing countries. In Senegal, one person in ten, regardless of ethnicity, geographical origin, or social class, carries the sickle cell gene. The majority have inherited the disease from only one parent and show no signs of it. These are the carriers of the sickle cell trait (SCT). However, their union produces children with homozygous sickle cell disease (SS), with a 25% risk in each pregnancy. As a result, the prevalence of sickle cell disease is rising steadily; around 1700 children are born with sickle cell disease in Senegal every year [4]. In the absence of appropriate management of this form of SS, 50% of children die before the age of 5. Sickle cell patients are more susceptible to infections, which, along with vaso-occlusive accidents and worsening of chronic anemia, are among the complications, sometimes serious, that can affect most organs. Bone tissue damage is widespread in sickle cell disease, with 27% of children and 41% of adults affected by osteonecrosis. It is linked to the compensatory expansion of the bone marrow and is systematically manifested by the expansion of bone loss. The remaining trabeculae are then spaced to compensate for the bone loss [5]. Although damage to the femoral head is the most common, damage to the bones of the face and mandible has also been widely documented [6]. Radiographically, these changes are manifested by a reduction in bone density and the spacing of residual trabeculae. Other changes reported in the maxilla include radiopaque and radiolucent areas [6]. Today, with the advent of digital radiography, dentists can analyze bone and tooth characteristics to detect early or subtle manifestations of the disease. Digital dental X-rays provide images of basal and alveolar bone at relatively high spatial resolution. In addition, because of the potential of panoramic radiography to provide a horseshoe-shaped image of the entire mandible and maxilla, unrolled on film from one mandibular condyle to the other, it is the examination of the first choice for radiological exploration of the facial mass [7]. To the best of our knowledge, several studies published on sickle cell disease throughout the world, particularly in Senegal, have focused for the most part on infections in general. However, few studies have focused on bone changes in the mandible, particularly in children [7]. Since radiology is a widely used diagnostic tool in dentistry, it may enable early detection of bone changes that point towards a diagnosis of sickle cell disease.

Given the possible bone changes in the mandible during sickle cell disease, what is the possible role of dental radiology in assessing these changes for the early diagnosis of SS sickle cell disease in children?

This study aimed to investigate bone changes in the mandible associated with

SS sickle cell disease in a Senegalese juvenile population.

2. Materials and Methods

This was a comparative study, with the study population consisting of "healthy" sickle cell and non-sickle cell children aged between 5 and 15 years.

Two groups were set up: a case group made up of subjects with SS sickle cell disease and a control group made up of non-sickle cell disease or "healthy" subjects. The study took place at the pediatric odontology department of the Albert Royer National Children's hospital and at the pediatric odontology clinic of the Institut d'Odontostomatologie.

The following eligibility criteria were defined for the selection of the two groups.

- Case group

  The following subjects have been selected:
  - sickle cell disease with the SS form;
  - with usable panoramic radiographs;
  - who agreed to take part in the study through parental consent.
- Control group

  The subjects are selected from patients:
  - who came to the pediatric odontology department of the Albert Royer National Children's hospital and the IOS Paediatric Odontology Clinic for oral care and who required a panoramic radiograph to complement the clinical examination;
  - who had no sickle cell gene;
  - who had agreed to participate in the study through informed parental consent;
  - who did not suffer from general or bone diseases?

  Subjects who did not meet these criteria were not included.

  The control group was matched on age.

Sampling was systematic and non-probabilistic. All subjects attending the pediatric odontology department of the Albert Royer National Children's Hospital and the IOS pediatric odontology clinic, and who met the previously established selection criteria, were selected.

The size was calculated according to the Schwartz formula: $n = (\varepsilon\alpha)^2 pq / I^2$ which is used in cross-sectional studies where $\varepsilon\alpha$ = reduced deviation = 1.96; p = proportion prevalence of SS sickle cell children is = 10%; q = the complement = 90%; I = precision = 8%. These parameters gave a sample size of 35. To increase power, we increased the sample size to 50, bringing it to 100 for the 2 groups.

- The variables studied were sociodemographic and radiographic characteristics:
  - The socio-demographic variables were age, expressed as several years, and sex, which is a dichotomous variable (girl/boy).
  - The radiographic variables were radiographic changes to the mandible

and bone density. The radiographic changes concerned radiolucent areas, radiopaque areas and decorticalisation of the mandibular canal (Figure 1).

They are classified as follows:

– Radiolucent areas: homogeneous, well-defined dark areas located along the body of the mandible or in the apical region of the teeth (Figure 2).
– Radiopaque areas: well-defined, homogeneous areas located along the body of the mandible or in the apical region of the teeth.
– Decorticalisation or absence of corticalisation of the mandibular canal: the upper and lower radiopaque lines bordering the mandibular canal are not visible.

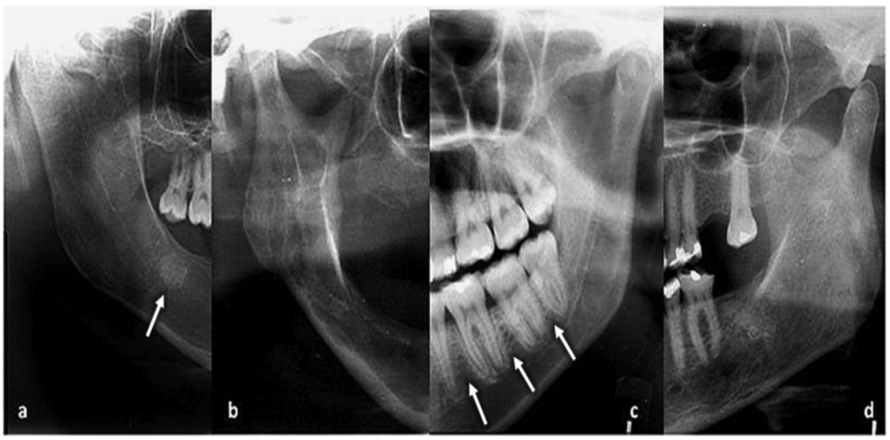

Figure 1. Cropped panoramic radiograph showing bone changes in sickle cell patients [13]. a. Radiopaque area; b. Spacing of bone trabeculae; c. Horizontal arrangement of bone trabeculae; d. Absence of corticalization of the mandibular canal.

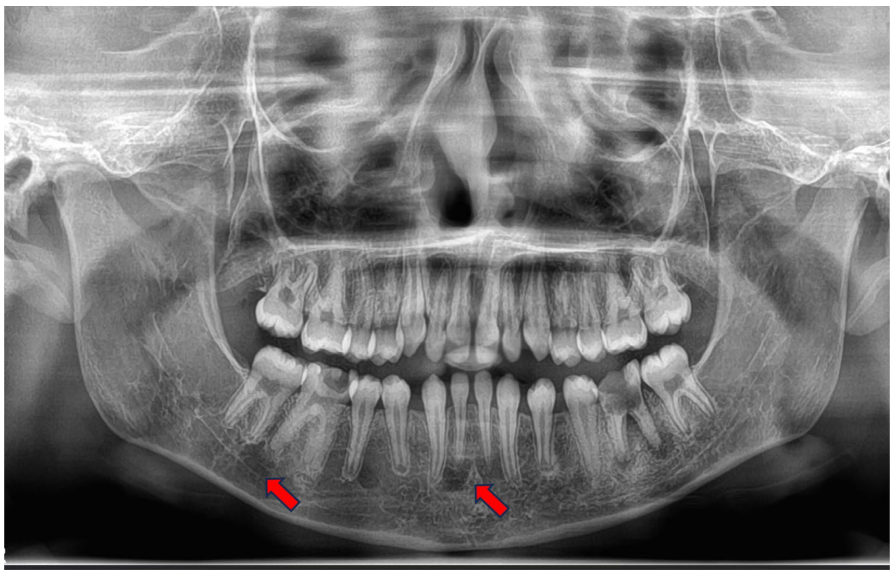

Figure 2. Panoramic radiograph of a sickle cell patient showing radiolucent areas. A panoramic radiograph of a 12-year-old child with sickle cell disease. The red arrows represent radiolucent images at the apical level of the teeth.

Data were collected from radiographs taken on the selected patients. The examination was carried out using a Carestream CS 9600 radiography machine. X-rays were taken by an experienced radiology technician to reduce image distortion to as much as possible, by the manufacturer's protocol. The images were viewed directly on the computer screen using the image-reading software, CS 3D imaging®, version 8.

The radiographs were analyzed by two examiners, a dental surgeon specializing in dentomaxillofacial radiology and a pediatric dentist. This study was approved by the university's local study committee. Anonymity and personal data protection rules were respected.

Data Analysis and Processing

Data collection and statistical analysis were carried out using Jamovi 2.3.28. Results for categorical variables are expressed as percentages and quantitative variables as means ± standard deviation. The Chi^2 test or the Fischer test was used to estimate the association between the qualitative variables. The significance level was set at a p-value of less than 0.05.

3. Results

The study population is 55% boys and 45% girls. The average age of the study population was 10.01 ± 2.86 years.

A quarter of the children had a clear radiolucent area of the body of the mandible. In children with sickle cell disease, this represented 46% (n = 24) and 2% (n = 1) in children without sickle cell disease, with a statistically significant difference ($p < 0.001$) (Table 1). There was no significant difference according to sex (p= 0.966).

Table 1. Radioclar zones of the mandibular body.

Sickle cell disease	Radioclar zones of the mandibular body		p
	yes n (%)	no n (%)	
yes n (%)	24 (48)	26 (52)	
no n (%)	1 (2)	49 (98)	<0.001
total n (%)	25 (25)	75 (75)	

Difference table showing an association with the fisher test between ss sickle cell disease and radiolucent images of the mandibular body.

Less than 1/3 (29%) of the children had a clear radiolucent area at the apex. Of these, 54% were sickle cell patients compared with 4% of non-sickle cell patients, with a significant difference ($p < 0.001$) (Table 2). There was no significant difference according to sex ($p = 0.744$). One in 10 children with sickle cell disease had a radio-opaque area of the mandibular body, compared with none in children without sickle cell disease, with no significant difference ($p = 0.052$) (Table 3). Almost 1/3 of children (28%) had a radio-opaque area at the apex, with a statisti-

cally significant difference ($p < 0.001$). There was no significant difference according to sex. Decortication of the mandibular canal was observed in almost one child in three (30%). In children with sickle cell disease, more than one child in two (56%) had this condition, compared with 6% in children without sickle cell disease, with a significant difference ($p < 0.001$) (Table 4).

Table 2. Radiopaque area.

Sickle cell disease		Radiopaque area		Total
		yes	no	
yes	n	5	45	50
	%	10	90	100
no	n	-	50	50
	%	-	100	100
Total	n	5	95	100
	%	5	95	100

$p <$ 0.001 difference table showing an association with the fisher test between ss sickle cell disease and radiopaque images of the mandibular body.

Table 3. Distribution of radiolucent areas in the dental apexes.

Sickle cell disease	Radiolucent areas in the dental apexes		Total
	yes	no	
yes	27	23	50
no	2	48	50
Total	29	71	100

$p <$ 0.001 difference table showing an association with the fisher test between ss sickle cell disease and radiolucent images of the dental apexes.

Table 4. Absence of corticalization of the mandibular canal.

Sickle cell disease		Absence of verticalization		Total
		yes	no	
yes	n	27	23	50
	%	54	46	100
no	n	3	47	50
	%	6	94	100
Total	n	30	70	100
	%	30	70	100

$p <$ 0.001.

4. Discussion

Changes in bone microarchitecture and bone development were assessed using

digital panoramic radiography. The results indicate that sickle cell disease causes bone loss and anatomical changes irrespective of the sex of the child. The mean age of the entire study population was 10.01 ± 2.86 years. Apart from systematic neonatal screening, sickle cell disease is rarely diagnosed before the age of 2 years. In our setting, the early discovery of sickle cell disease depends on how early the warning signs are

The results compiled showed that a quarter of children had a radiolucent area of the body of the mandible (representing 46% in children with sickle cell anemia compared with 2% in children without sickle cell anemia) and less than 1/3 (29%) of children had a radiolucent area at the apex (with 54% in children with sickle cell anemia compared with 4% in children without sickle cell anemia).

An increased number of radiolucent areas due to alterations in the trabecular bone of SS sickle cell patients has been reported in the literature [5] [8]-[13]. Erythroid hyperplasia in sickle cell disease causes trabecular destruction leading to low bone density. Fourier digital analysis of dental radiographs is an effective method of identifying individuals with sickle cell disease [14]. Radiographically, these changes appear as radiolucent areas usually seen between the apices of posterior teeth and the lower mandibular margin [15].

The results of the study also revealed that one in 10 children with sickle cell disease had a radio-opaque area of the body of the mandible, compared with none in children without sickle cell disease, and almost 1/3 of children (28%) had a radio-opaque area at the apex, with a statistically significant difference ($p < 0.001$).

Bone changes in the acute phase are not usually seen on conventional radiographs. After a few months, as a result of decalcification, well-defined radiolucent areas may appear, which may be surrounded by an osteocondensing border [15]. Subsequently, radio opacities linked to the formation of sclerotic bone may also be observed [15]. The mandible is the site most affected, with a preferential location along the vascular canals or dental apices [15]. Dental and facial pain, with a wider range of severity, is frequently associated with the process of bone infarct formation. A panoramic radiograph cannot confirm the diagnosis of a bone infarction during the acute phase. However, in a study of 71 subjects with sickle cell disease and 52 control subjects, radiopaque areas were observed in 30 subjects with sickle cell disease compared with 7 control subjects, with statistically significant differences between the sickle cell disease subjects and the control group [13]. The posterior region of the mandible was the most frequent location, corroborating the results of previous studies [13] [14]. However, this finding should be interpreted with caution because, when using panoramic radiographs, it is difficult to distinguish between different radiopaque changes, such as dense bone islands and salivary lithiasis of the submandibular and sublingual glands [13]. Further investigations may be necessary to establish a differential diagnosis, such as pulp vitality tests to exclude condensed osteitis and occlusal radiographs. Changes in the periosteum and adjacent soft tissues may also be present, making it difficult to make a differential diagnosis from osteomyelitis [3] [5] [7].

The results showed that decortication of the mandibular canal was observed in almost one child in 3 (30%) and that children with sickle cell disease had more damage to the upper (54% compared with 16%) and lower (50% compared with 12%) walls of the mandibular canal than children without sickle cell disease.

The mandibular canal is usually observed on panoramic radiographs as a radiolucent band defined by two parallel radiopaque lines corresponding to its upper and lower cortical limits. Hazza *et al.* [15], in a study of 54 panoramic radiographs of subjects with sickle cell disease, found no mandibular canal cortex in 82% of these subjects compared with 8% of their controls. The work of Neves *et al.* [6] [13] showed the absence of mandibular canal corticalisation to be more prevalent in SS sickle cell patients. Although considerable variation in mandibular canal corticalization would be expected, the differences may be related to decreased bone mineral mass and increased bone trabecular spacing in SS patients.

5. Conclusion

Analysis of the results opens up definite prospects, particularly for the early detection of osteoporotic changes in subjects with SS sickle cell disease and better management of the latter. In countries south of the Sahara, including Senegal, where the disease is a major public health problem, radiological diagnosis, in particular panoramic radiography, must be integrated, especially in the current multidisciplinary context of management of sickle cell disease patients. A study of bone density by fractal dimension would provide further confirmation of the radiographic changes in the mandible associated with sickle cell disease.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Seiller, J., Merle, B., Fort, R., Virot, E., Poutrel, S., Hot, A., *et al.* (2021) L'ostéoporose dans la drépanocytose: Caractéristiques et enjeux. *Revue du Rhumatisme*, **88**, A290-A291. https://doi.org/10.1016/j.rhum.2021.10.495

[2] World Health Organisation (2006) Fifty-Ninth World Health Assembly (A59/9), Provisional Agenda Item 11.4. Sickle-Cell Anaemia: Report by the Secretariat.

[3] Streetly, A., Latinovic, R., Hall, K. and Henthorn, J. (2008) Implementation of Universal Newborn Bloodspot Screening for Sickle Cell Disease and Other Clinically Significant Haemoglobinopathies in England: Screening Results for 2005-7. *Journal of Clinical Pathology*, **62**, 26-30. https://doi.org/10.1136/jcp.2008.058859

[4] Thiam, L., Dramé, A., Coly, I.Z., Diouf, F.N., Seck, N., Boiro, D., *et al.* (2017) Profils épidemiologiques, cliniques et hématologiques de la drépanocytose homozygote SS en phase inter critique chez l'enfant à Ziguinchor, Sénégal. *Pan African Medical Journal*, **28**, Article 208. https://doi.org/10.11604/pamj.2017.28.208.14006

[5] Almeida, A. and Roberts, I. (2005) Bone Involvement in Sickle Cell Disease. *British Journal of Haematology*, **129**, 482-490. https://doi.org/10.1111/j.1365-2141.2005.05476.x

[6] Neves, F.S., de Almeida, D.A., Oliveira-Santos, C., dos Santos, J.N., Toralles, M.B.P.,

da Silva, M.C.B.O., *et al.* (2011) Radiographic Changes of the Jaws in HbSS and HbSC Genotypes of Sickle Cell Disease. *Special Care in Dentistry*, **31**, 129-133. https://doi.org/10.1111/j.1754-4505.2011.00195.x

[7] Foucart, J., Felizardo, R., Pizelle, C. and Bourriau, J. (2012) Indications des examens radiologiques en orthopédie dento-faciale. *L'Orthodontie Française*, **83**, 59-72. https://doi.org/10.1051/orthodfr/2012001

[8] Diagne, I., Lima Soares, G.M.M., Gueye, A., Diagne-Gueye, N.R., Fall, L., Ndiaye, O., *et al.* (2000) Infections in Senegalese Children and Adolescents with Sickle Cell Disease: Epidemiological Aspect. *Dakar Medical*, **45**, 55-58.

[9] Diagne, I., Ndiaye, O., Moreira, C., Signate-Sy, H., Camara, B., Diouf, S., *et al.* (2000) Les syndromes drépanocytaires majeurs en pédiatrie à Dakar (Sénégal). *Archives de Pédiatrie*, **7**, 16-24. https://doi.org/10.1016/s0929-693x(00)88912-5

[10] Guedenon, K.M., Akolly, D.A.E., Fiawoo, M., Dossou, F.C., Takassi, O.E., Djadou, K.E., *et al.* (2024) Crise vaso-occlusive drépanocytaire sévère: Aspects cliniques, étiologiques et thérapeutiques au CHU Sylvanus Olympio de Lomé. *The Pan African Medical Journal*, **47**, Article 162. https://doi.org/10.11604/pamj.2024.47.162.33754

[11] Sadat-Ali, M. and Al Elq, A.H. (2007) Sickle Cell Anaemia: Is It a Cause for Secondary Osteoporosis? *West African Journal of Medicine*, **26**, 134-137.

[12] Kavadia-Tsatala, S., Kolokytha, O., Kaklamanos, E.G., Antoniades, K. and Chasapopoulou, E. (2004) Mandibular Lesions of Vasoocclusive Origin in Sickle Cell Hemoglobinopathy. *Odontology*, **92**, 68-72. https://doi.org/10.1007/s10266-004-0036-3

[13] Neves, F.S., Passos, C.P., Oliveira-Santos, C., Cangussu, M.C.T., Campos, P.S.F., Nascimento, R.J.M., *et al.* (2012) Correlation between Maxillofacial Radiographic Features and Systemic Severity as Sickle Cell Disease Severity Predictor. *Clinical Oral Investigations*, **16**, 827-833. https://doi.org/10.1007/s00784-011-0577-0

[14] Gillis, M.V. and West, N.M. (2004) Sickle Cell Disease and Trait: An Increase in Trabecular Spacing, a Case Study. *Journal of Dental Hygiene*, **78**, 355-359.

[15] Hazza'a, A. and Al-Jamal, G. (2006) Radiographic Features of the Jaws and Teeth in Thalassaemia Major. *Dentomaxillofacial Radiology*, **35**, 283-288. https://doi.org/10.1259/dmfr/38094141