Journal of Clinical Neuroscience 17 (2010) 182–186

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

Morphometry of the thoracolumbar vertebrae in sickle cell disease

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ARTICLE INFO

Article history:
Received 19 March 2009
Accepted 17 May 2009

Keywords:
Morphometry
Osteoporosis
Pedicle
Pedicle screw
Sickle cell disease
Vertebrae

ABSTRACT

Patients with sickle cell disease (SCD) who have deformities and vertebral fractures due to osteoporosis may require surgery. Spinal surgeons must become familiar with the vertebral morphometry of patients with SCD and to that aim we have examined the morphometry of the thoracolumbar spine in these patients.

A cohort of 100 patients with SCD was examined using plain thoraco lumbar anteroposterior/lateral radiographs and dual energy X-ray absorptiometry (DEXA). Vertebral morphometry (vertebral body diameters, pedicle, spinal canal and deformity) was assessed for different age groups. Results were compared to published studies of healthy subjects.

The vertebral dimensions for the 16–20-year and the 21+-year-old groups were significantly smaller for females than males at most spinal levels, while measurements in the 6–10 years and 11–15 years age groups were similar across both sexes at most levels. No significant statistical difference was found between the diameters of the right and left pedicles. With the exception of the sagittal diameter, most of the dimensions of the vertebral bodies measured in SCD patients were less than those of healthy individuals; multiple deformities were also observed. Low bone density was noted in 32 patients.

Our data highlight the differences in vertebral bone mineral density, anatomy and deformities in patients with SCD compared to healthy individuals. When considering surgical intervention for patients with SCD, it is important that pre-operative radiography and planning is undertaken, and that the surgeon is familiar with the geometry of the pedicles of the thoracolumbar vertebrae necessary for the safe insertion of pedicle screws. Osteoporosis must be considered when planning surgical interventions in these patients.

1. Introduction

Sickle cell disease (SCD) is a hemoglobinopathy that causes end-arterial thromboses and leads to tissue hypoxia and osteonecrosis. Chronic hemolysis results in marrow hyperplasia with subsequent bony deformities. The prevalence of osteopenia and osteoporosis in young adults who have SCD is extremely high.[1] Given that patients with SCD now survive well into their 50s, they are likely to face the long-term sequelae of osteoporosis, including vertebral fractures. This has a potential impact on public health, as such fractures and deformities often require surgical intervention to correct them, and if unrecognized will most likely result in significant morbidity. Spinal surgeons would therefore benefit from familiarity with the vertebral morphometry of patients with SCD.

In this retrospective study, we aimed to evaluate the thoracolumbar vertebral morphometry of children and young adults in whom the degenerative changes of SCD have not yet became significant. To our knowledge, this is the first study examining the morphometry of the thoracolumbar vertebrae of patients who have SCD.

2. Materials and methods

The 100 participants in this retrospective study were patients with SCD who had been seen and treated at our institution. The study was approved by the ethics committee of the Mustafa Kemal University School of Medicine. In order to maintain the heterogeneity of the sample, the first 50 female and 50 male patients were studied, regardless of their age. All patients had hemoglobin sickle cell (HbSS) disease. Plain anteroposterior and lateral radiographs of the thoracolumbar spine, centered at L2, were taken from a

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doi:10.1016/j.jocn.2009.05.010

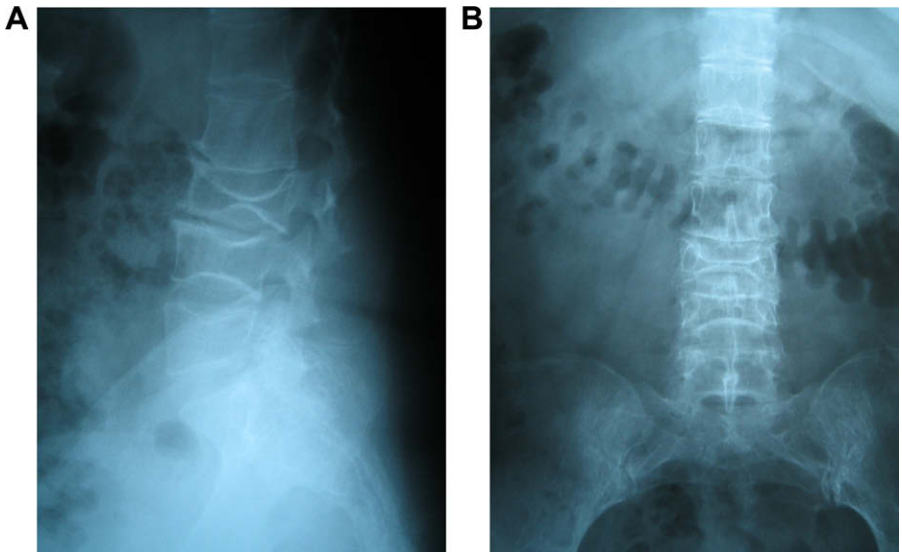

Fig. 1. (A) Lateral and (B) anteroposterior radiographs of the lumbar spine of a 30-year-old woman with sickle cell disease showing generalized demineralization and the typical "fish-shaped" vertebral bodies.

standard distance of 110 cm to determine vertebral morphometry. The radiographs were anonymized and independently evaluated by two observers (YS, AK). Biconcave narrowing ("fish vertebrae", "H vertebrae"; Fig. 1), intervertebral disc calcifications, kyphosis (compression fracture; Fig. 2) and other deformities (Fig. 3) were evaluated. The dimensions were measured to the nearest one-tenth of a millimeter using a Vernier caliper. Three measurements were taken for each parameter and their averages calculated. The patients were grouped according to age (6–10 years, 11–15 years, 16–20 years and 21+ years), and all of the measured parameters were analyzed using the analysis of variance test. The right and left pedicles, as well as male and female patients, were compared at every level using an independent *t*-test. A result of $p < 0.05$ was considered statistically significant. The results were then compared to the published findings of the vertebral morphometry of healthy patients. Based on these data, additional measurements were then taken from the existing radiographs. The following diameters were measured on the anteroposterior radiographs:

- interpedicular distance – the distance between the medial borders of the pedicles
- transverse diameter of the vertebral body – the level of the narrowest part of the waist of the vertebral body
- transverse diameter of the pedicle – the pedicle width
- cephalocaudal diameter of the pedicle – pedicle height (Fig. 4A).

On the lateral radiographs, the sagittal diameter of the spinal canal, which is taken from the spinolaminar line to the posterior border of the vertebral body, and the sagittal diameter of the vertebral body, which is the normal anteroposterior diameter on lateral plain film, were also measured (Fig. 4B).

In this comprehensive study, dual-energy X-ray absorptiometry (DEXA) was used to assess the bone mineral density (BMD) of the lumbar spine in each of our 100 patients (Z-scores). Given that patient age varied widely, the vertebral BMD measurements were classified as either normal (Z-score $\geqslant -2.0$) or low (Z-score < -2.0).

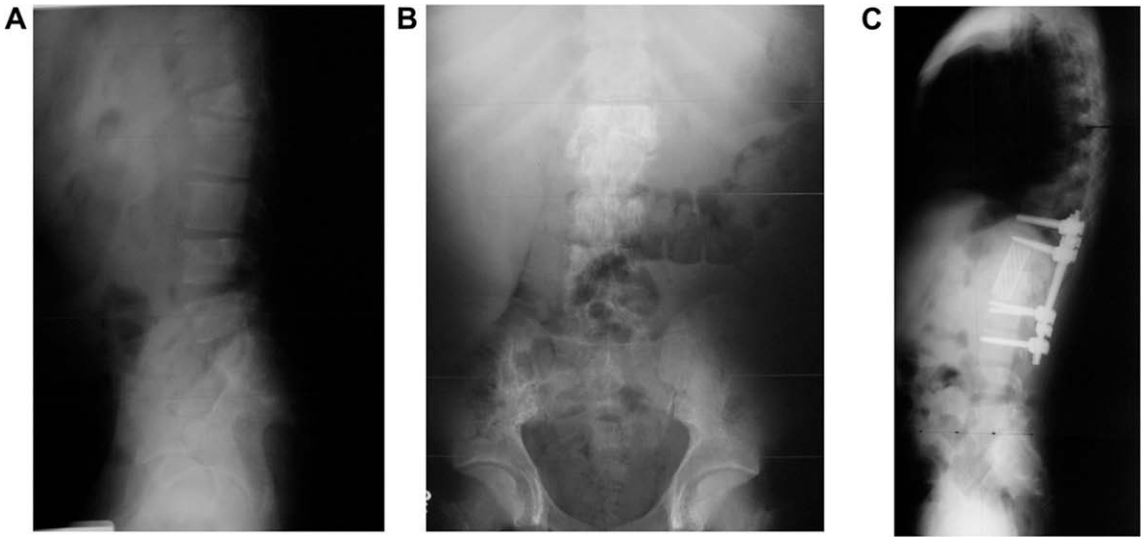

Fig. 2. Pre-operative (A) lateral and (B) anteroposterior radiographs of the lumbar spine of a 19-year-old boy showing necrosis, collapse and resorption of the Ll vertebral body. (C) Post-operative lateral radiograph showing the instrumentation and correction of the deformity.