Spine Deformity
www.spine-deformity.org

Spine Deformity 2 (2014) 410–414

Cervical Lordosis Actually Increases With Aging and Progressive Degeneration in Spinal Deformity Patients

Han Jo Kim, MD[a], Lawrence G. Lenke, MD[b,*], Yasushi Oshima, MD[c], Tapanut Chuntarapas, MD[d], Addisu Mesfin, MD[e], Stuart Hershman, MD[f], Jeremy L. Fogelson, MD[g], K. Daniel Riew, MD[b]

[a]*Hospital for Special Surgery, Department of Orthopaedic Surgery, 535 East 70th Street, New York, NY 10021, USA*
[b]*Department of Orthopaedic Surgery, Washington University School of Medicine, 660 S Euclid Avenue, Campus Box 8233, Saint Louis, MO 63110-1010, USA*
[c]*Department of Orthopaedic Surgery, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan*
[d]*Department of Neurosurgery, Fort Suranaree Hospital, 555 Soi Ruamjit, Ractchasrima Road, Nakornchaisri Dusit Bangkok, 10300, Thailand*
[e]*Department of Orthopaedics and Rehabilitation, University of Rochester, 601 Elmwood Ave., Box 665, Rochester, NY 14642, USA*
[f]*Florida Spine Specialists, 6000 North Federal Highway, Fort Lauderdale, FL 33308, USA*
[g]*Department of Neurologic Surgery, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, USA*

Received 20 September 2012; revised 1 May 2014; accepted 8 May 2014

Abstract

Study Design: Retrospective.
Objectives: The authors hypothesized that cervical lordosis (CL) would decrease with aging and increasing degeneration.
Summary of Background Data: It is theorized that with age and degeneration, the cervical spine loses lordosis and becomes progressively more kyphotic; however, no studies support these conclusions in patients with various spinal deformities.
Methods: The authors performed a radiographic analysis of asymptomatic adults (referring to their cervical spine) of varying ages, with differing forms of spinal deformity to the thoracic/lumbar spine to see how cervical lordosis changes with increasing age. A total of 104 total spine EOS X-rays of adult (aged >18 years) spinal deformity patients without documented neck pain, prior neck surgery, or cervical deformity were reviewed. The researchers only reviewed EOS X-rays because they allow complete visualization from occiput to feet. Cervical lordosis, standard Cobb measurements, sagittal balance parameters, and cervical degeneration were quantified radiographically by the method previously described by Gore et al. Statistical analysis was performed with 1-way analysis of variance to compare significant differences between groups aged <40, 40–60 and >60 years as well as changes in sagittal balance. A p-value $< .05$ was considered significant.
Results: Average CL actually increased with increasing age (10.3 ± 14.7, 15.4 ± 15.1, and $23.3 \pm 1.6.7$ for age < 40, 40–60, and > 60 years, respectively; $p < .05$). Average cervical degeneration score increased at all disc space levels from C2 to C7 across age groups (0.7 ± 1.2, 9.9 ± 69, and 16.3 ± 8.9 for age <40, 40–60, and >60 years, respectively; $p < .01$), with the highest degeneration at the C5–6 and C6–7 disc spaces (3.7 ± 3.3 and 3.2 ± 2.9, respectively; $p < .01$). This increase did not correlate with the increase in CL seen with aging ($r = 0.02$; $p = .84$).
Conclusions: Cervical lordosis increased with aging in adult spinal deformity patients. There was no relationship between cervical degeneration and lordosis despite the strong relationship seen between increasing CL in older age groups.

Keywords: Cervical spine; Sagittal alignment; Degeneration; Increasing age

Author disclosures: HJK (consultant on the Spine Innovation Advisory Board of Medtronic, Inc); LGL (patents from Medtronic [unpaid]; royalties from Medtronic and Quality Medical Publishing; travel reimbursement monies related to meetings/course from BroadWater, Medtronic, SRS); YO (none); TC (none); AM (none); SH (none); JLF (none); KDR (expert testimony; grants from Medtronic for IDE participation; royalties from Osprey, Medtronic, Biomet; stock/stock options with Osprey, Expanding Orthopedics, Spineology, Spinal Kinetics, Amedica, Nexgen Spine, Vertiflex, Benvenue, Paradigm Spine, PSD).

*Corresponding author. Department of Orthopaedic Surgery, Washington University School of Medicine, 660 S Euclid Avenue, Campus Box 8233, Saint Louis, MO 63110-1010, USA. Tel.: (314) 747-2535; fax: (314) 747-2599.

E-mail address: lenkel@wudosis.wustl.edu (L.G. Lenke).

2212-134X/$ - see front matter © 2014 Scoliosis Research Society.
http://dx.doi.org/10.1016/j.jspd.2014.05.007

Introduction

The contribution of regional spinal alignment on global sagittal balance is beginning to be understood. For example, it is well established that patients with flatback syndrome have positive sagittal imbalance owing to a lack of lumbar lordosis. Alternatively, patients with hyperkyphosis of the thoracic spine might develop hyperlordosis in the lumbar spine in an attempt to maintain normal sagittal balance. Although these relationships are understood in the thoracic and lumbar spine, little is known about the role cervical lordosis (CL) has in global sagittal balance and what factors contribute to changes in CL over time. In addition, the interplay between the occiput and the thoracic spine in relation to CL is poorly understood.

One challenge in understanding regional alignment of the cervical spine is the lack of studies defining normative values. This is complicated by greater positional variations in the cervical spine, which has a smaller amount of skeletal and soft tissue restraints compared with the thoracic and lumbar spine. Controversy exists regarding whether the cervical spine becomes more kyphotic or lordotic with age and degeneration [1-3]. Studies have equated cervical degeneration to cervical kyphosis, but this has been confounded by the phenomenon of ''posting,'' which is the relative kyphotic position a patient's cervical spine may take with disc protrusions, causing neck pain or radiculopathy [4]. Intuitively, this has led to an assumption that increasing age produces increasing degeneration, and therefore kyphosis. On the contrary, cross-sectional, longitudinal, and anatomical studies have demonstrated increasing CL with aging [1,5,6]. However, none of those studies addressed how the cervical spine changes with increasing age in patients with spinal deformities affecting the thoracic spine, thoracolumbar junction, or lumbar spine.

With increasing understanding of the relationship between regional parts of the spine, spinal deformity patients are a unique subset of patients because of their underlying deformities. Therefore, the purpose of this study was to perform a cross-sectional observational study on cervical sagittal alignment in spinal deformity patients and its relationship to radiographic degeneration. The authors hypothesized that with advanced age the cervical spine would become progressively more kyphotic and show increased degeneration.

Materials and Methods

Between January and August, 2011, EOS (EOS Imaging, Paris, France) total body radiographs were obtained for 201 consecutive adult spinal deformity patients. The authors used EOS radiographs because they allow complete visualization from the occiput to the feet. All X-rays were taken with a standardized protocol for the EOS machine, which is with the hands touching the clavicles and with patients being asked to stand upright as naturally as possible. (A bar is provided for them to hold on to if they are unsteady.) EOS films were reviewed for 104 patients >18 years of age without documented neck pain, prior neck surgery, or deformity. Of these, 18 were preoperative and 86 were postoperative (which included 19 patients after revision surgery). Diagnoses ranged from Scheuermann kyphosis ($n = 8$) to sagittal imbalance ($n = 7$), flatback syndrome ($n = 6$), coronal imbalance ($n = 8$), adolescent idiopathic scoliosis ($n = 18$), and adult idiopathic scoliosis ($n = 57$). Cervical lordosis, standard Cobb measurements, sagittal vertical axis (SVA), and cervical degeneration were quantified radiographically by the method previously described by Gore et al. [1], which consists of 3 main radiographic criteria: disc space height, end plate sclerosis, and the presence of anterior and posterior osteophytes. The designated disc space evaluated is given a score between 0 and 3 for the 4 criteria mentioned; thus, scores can range from 0 to 12/level. Degeneration scores were assessed at every level from C2 to C7. A composite score was then calculated based on the sum of the degeneration scores of the 5 disc spaces being evaluated (the worst possible score being 60 and best being 0). For example, if the sum of all the disc spaces added up to 30, the composite score was 30 of 60, making the degeneration index a raw value of 30 or a 0.50-weighted value. Cervical lordosis was measured using the Harrison method, which measures the angles between the posterior borders of C2 and C7 [7]. Two surgeons independent of the surgical team performed all radiographic measurements.

Statistical analysis was performed using 1-way analysis of variance to examine for significant differences between age groups <40, 40–60 and >60 years for variables that met the assumption of normality and using the nonparametric Kruskal-Wallis test for those that did not meet this assumption. Post hoc analyses were then performed to examine for statistical differences between particular age groups. The authors performed bivariate analysis with Pearson correlation to examine for correlations between CL, sagittal balance, age, and degeneration. A p-value $< .05$ was considered significant. A multivariate regression model was developed to examine which variables were associated with CL. Variables included in the model were age, sex, body mass index, preoperative Oswestry Disability Index (ODI) and Scoliosis Research Society score, and SVA. Because of the exploratory nature of the analysis, variables that maintained $p = .15$ were retained in the model. Variables that reached adjusted $p \leqslant .05$ were deemed statistically significant predictors. Normality of SVA was tested using Shapiro–Wilk test. This showed $p = .648$, demonstrating that SVA was normally distributed. Statistical analyses were performed using SPSS version 20.0 (IBM Corp, Armonk, NY).

Results

Demographic data included 104 patients with an average age of 52.1 years. There were 92 females and 12 males.