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Association of Burners with Cervical Canal and Foraminal Stenosis*

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ABSTRACT

The purpose of this study was to determine whether the burner phenomenon is associated with cervical canal and foraminal stenosis in a scholastic population. Lateral cervical radiographs were reviewed for 64 athletes, 15 to 18 years of age, who had sustained at least one burner. Controls consisted of age-matched athletes who had sustained head or neck trauma without evidence of the burner phenomenon ($N = 32$). Pavlov ratios were calculated for levels C-3 through C-6; both mean minimum and mean average ratios were determined. Available oblique radiographs from both the study ($N = 31$) and control ($N = 15$) groups were then used to calculate the foramen/vertebral body ratio—a measure of relative foraminal height. Significant differences were found between the burner and control groups for the mean minimum and mean average Pavlov ratios and foramen/vertebral body ratios. Scholastic athletes sustaining the burner phenomenon have an increased risk of cervical canal and foraminal stenosis as measured by the Pavlov and foramen/vertebral body ratios, respectively. The foramen/vertebral body ratio is an easily reproducible and reliable means of assessing foraminal dimensions from oblique radiographs and controls for x-ray magnification and rotation. Foraminal stenosis assessment may prove useful in predicting burner risk, especially in athletes with extension-compression injuries.

"Burners," or "stingers", also known as traumatic upper extremity paresthesias, are commonly seen in contact athletes, including football players and wrestlers. The incidence of a burner at some point in the career of college football players has been reported to be as high as 65% (131 of 201 athletes).[15] The burner phenomenon, which usually results after head or shoulder contact with another athlete or an object, involves the athlete experiencing a sharp burning pain that often radiates distally into the ipsilateral arm or hand.[2,13] Temporary paralysis of the arm can occur, with recovery ensuing usually within minutes of the injury.[13] Differential injury diagnosis includes cervical radiculopathy, cord contusion, and brachial plexus injury. Confusion exists as to the site of the abnormality. The lesion is principally thought to occur at either the upper trunk[1,8,15] or division (A. Dossett et al., unpublished data, 1995) levels of the brachial plexus, or at the root level.[11,12,14,16] Three chief mechanisms of injury have been proposed[15]: nerve root compression in the neural foramen (that is, extension-compression, or "root," injuries), brachial plexus stretch (that is, traction, or plexus, injuries), and a direct blow to the plexus.

Cervical spine hyperextension with or without concomitant lateral flexion is thought to compress or pinch the nerve root at the intervertebral foramen. Extension-compression burners occur in more mature athletic populations (collegiate and professional).[7,12,16] They are generally associated with radiologic evidence of cervical disk disease. On examination, neck pain is frequently seen, as is a positive Spurling's test,[12,16] which evokes foraminal constriction and often reproduces the athlete's pain.[12]

Brachial plexus stretch injuries occur if the head is knocked away from the symptomatic side with concomitant ipsilateral shoulder depression. These injuries occur more commonly in younger (scholastic) athletes. Examination of these athletes reveals that neck pain is usually not a prominent feature and that a Spurling's test is negative.[12]

In 1992, Galinat et al. (unpublished data) reported that National Football League draftees with a history of burners have been shown to demonstrate smaller cervical canal ratios (as measured by the method of Pavlov et al.[10])

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than draftees without such a history. Because the Pavlov ratio (Fig. 1) incorporates spinal canal dimensions divided by the anteroposterior width of the adjacent vertebral body, inordinately larger vertebral bodies of sizable collegiate and professional football players may generate falsely low values.[4] Perhaps scholastic athletes with more physiologic vertebral body dimensions would give a more accurate depiction of cervical stenosis as defined by the Pavlov ratio. More recently, Meyer et al.[9] demonstrated that cervical canal stenosis is associated with a threefold risk of incurring extension-compression burner injuries, but no such association was found for plexus injuries. Similarly, Levitz et al.[7] reported that athletes with recurrent burners sustain root injuries and have associated cervical canal stenosis. The notion that canal narrowing accompanies increased foraminal constriction is verified in the association of canal stenosis with root but not with plexus injuries. Meyer et al.,[9] Kelly,[5] and Kelly et al.[6] have proposed that a narrow canal, with accompanying shortened pedicles, will lead to narrow foramina, thus increasing the risk of nerve root pinch or compression.

We sought a more sensitive instrument in predicting risk for the burner phenomenon, one that could readily measure foraminal dimensions from plain radiographs. Thus, we introduce the foramen/vertebral body ratio (Fig. 2) which is calculated by dividing the foraminal height, as seen on an oblique radiograph, by the height of the subjacent vertebral body. Like the Pavlov ratio, it is independent of x-ray beam distance and x-ray rotation. The purpose of this study was to determine whether the burner phenomenon is associated with canal or foraminal stenosis, or both, as measured by the Pavlov and foramen/vertebral body ratios, respectively, in a scholastic population.

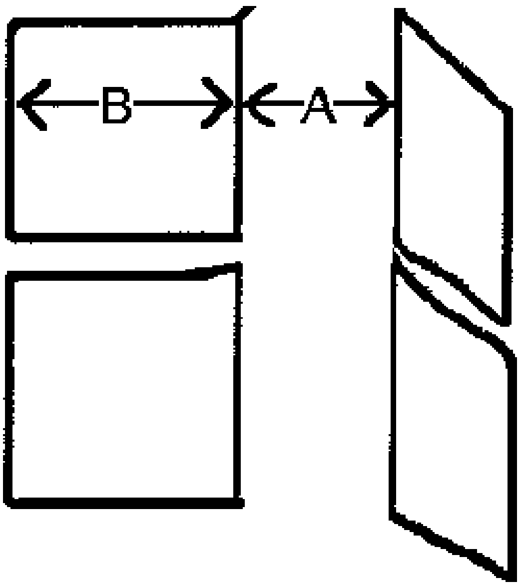

Figure 1. Pavlov ratio = A/B (lateral radiograph)

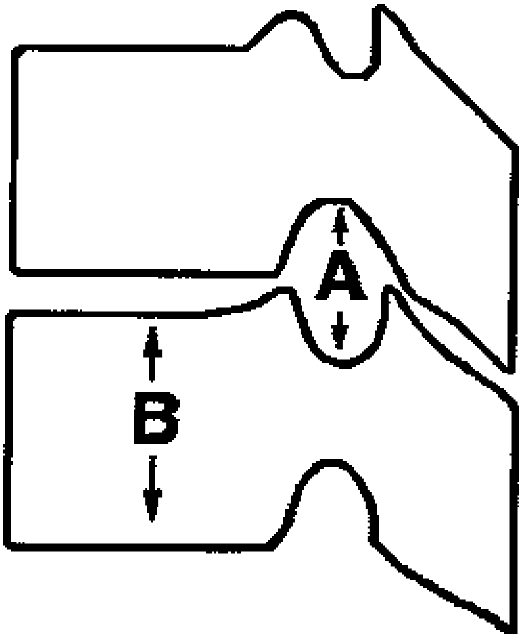

Figure 2. Foramen/intervertebral body ratio = A/B (oblique radiograph)

MATERIALS AND METHODS

Subjects

We reviewed the medical records of 97 scholastic football players and identified 64 patients in the specific age range of 15 to 18 years (mean, 16.6) who had sustained at least one burner. Controls consisted of age-matched (mean age, 16.4 years) football players and wrestlers who had sustained head and neck trauma without evidence of burner phenomenon ($N = 32$). The study was approved by the Temple University Institutional Review Board.

Data Collection

We reviewed AP radiographs of the 64 burner patients and excluded from this study patients who had congenital anomalies, instability, fractures, osteophytes, or significant degenerative changes. Pavlov ratios were then calculated for levels C-3 through C-6 from lateral cervical radiographs. Both mean minimum and mean average ratios were determined.

Available oblique radiographs from both the burner ($N = 31$) and control ($N = 15$) groups were then used to calculate the foramen/vertebral body ratio. This ratio is the maximal height of the foramen to the height of the subjacent vertebral body (Fig. 1). The vertebral height is measured at the midportion on the oblique radiograph. Foraminal/vertebral body ratios were calculated for C-3 through C-6, with the mean average ratios and mean minimum ratios determined. All measurements were conducted by one observer (JDK) and employed fine markings and direct measurements of radiographic dimensions.

Care was taken to round off middle values to the next lowest tenth of a centimeter.

Intratester measurement reliability was determined by repeat measurements for spinal canal width, vertebral body width, intervertebral foraminal height, and vertebral body height for C-3 through C-6. Intratester intraclass correlation coefficients ranged from 0.92 to 0.96.

Reliability assessment of the radiographic angle for intervertebral foraminal height and vertebral body height was also completed. Oblique radiographs were taken at 30°, 45°, and 60° angles from the sagittal plane for one subject. Measurements were taken for C-3 through C-6. Results of a one-way analysis of variance revealed no significant differences in intervertebral foraminal height ($P = 0.44$) or vertebral body height ($P = 0.75$) among the three test angles tested. In other words, measurement of intervertebral foraminal height and vertebral body height was independent of radiographic angle.

Data Analysis

Data were analyzed using descriptive and inferential statistics. Pavlov and foramen/vertebral body ratio mean averages and mean minimum levels for C-3 through C-6 were analyzed. Differences between groups (control versus burner) were analyzed for significance with the independent t-test statistic. The SPSSPC+ statistical program (SPSS Inc., Chicago, Illinois) was used to analyze the data. The alpha level was set at $P \leq 0.05$, and all probability testing was completed in the null form.

RESULTS

The mean minimum Pavlov ratio ([plusm]SD) for controls was 0.94 (±1.5) and for the burner group was 0.875 (±0.110). The mean average Pavlov ratio for controls was 1.018 (±10.165) and for the burner group was 0.944 (±0.14). Significant differences existed between the control and burner groups for both the mean minimum ($t = -2.367$, $P = 0.02$) and mean average ($t = -2.398$, $P = 0.01$) cervical canal Pavlov ratios.

The mean minimum foramen/vertebral body ratio for controls was 0.72 (±0.07) and for the burner group was 0.65 (±.006). The mean average foramen/vertebral body ratio for controls was 0.79 (±0.05) and for the burner group was 0.73 (±0.06). The differences between the control and burner groups were significant for both the mean minimum ($t = 2.927$, $P = 0.007$) and mean average ($t = 2.54$, $P = 0.017$) foramen/vertebral body ratios.

DISCUSSION

Results of electrodiagnostic studies reveal the cause of burner phenomenon to be both root[11] and plexus[1] injuries. It is becoming increasingly apparent that two major subclassifications of injury exist: extension-compression (root) injuries and traction (plexus) injuries. While Dossett et al. (unpublished data, 1995), using MRI short tau inversion recovery (STIR) images, have demonstrated the zone of injury in traction injuries to be the division level of the plexus, the intervertebral foramen is the proposed site of extension-compression injuries. Extension and compression with ipsilateral lateral bending does, in fact, narrow foraminal dimensions, increasing the likelihood of cervical root pinch. Reproduction of these symptoms with Spurling's test and its concomitant foraminal constriction reinforce the notion that the foramen is the site of neural injury. In this study, both canal and foraminal stenosis were associated with all burners. Using scholastic athletes (ages 15 to 18), who possess relatively physiologic neck sizes, may avoid the potential confounding effect of large vertebral bodies in calculating the Pavlov ratio.[4]

Previous authors have assumed that canal stenosis indirectly reflects foraminal stenosis (that is, narrow canal = narrow pedicles = narrow foramina).[6,9] However, the foramen/vertebral body ratio directly measures relative foraminal dimensions.

A weakness of the present study was the lack of stratification of subjects into extension-compression (root) versus traction (plexus) injuries. Since Meyer et al.[9] have shown cervical canal stenosis to be associated with root injuries only, stratification of our study sample into root and plexus injuries would have likely shown even stronger association with canal stenosis for extension and compression injuries. Nonetheless, our data are consistent with those of previous investigators implicating the foramen as the site of injury for at least a subset of burner patients.[7,12,16]

For the lumbar spine, a significant positive correlation exists between compression of nerve roots and foraminal height. Specifically, Hasegawa et al.[3] in their anatomic study determined that lumbar nerve root compression occurred frequently if foraminal height fell below 15 mm. Cervical foramina could similarly be expected to demonstrate a threshold dimension at which compression occurs.

With increasing age, the following changes are noted to occur in both the cervical and lumbar spines: decreased intervertebral height, osteoarthritic changes in the facet joints, cephalad subluxation of the superior articular processes of inferior vertebrae, annulus protrusion, and ligamentum flavum buckling. All of these degenerative changes may effectively diminish foraminal dimensions sufficiently to cause compression of the spinal nerve root. Because extension-compression burners are considered to result from true root injuries, they would be expected to occur more often when there is foraminal constriction than would plexus burner injuries. Thus, the onset of degenerative changes with concomitant foraminal encroachment, or narrowing, would be expected to preferentially increase the incidence of extension-compression burners, rather than plexus injuries. This is indeed the case seen clinically. Watkins[16] and Reilly and Torg[12] noted the preponderance of burners in more mature athletes occurring secondary to the extension-compression mechanism. Similarly, foraminal stenosis secondary to degenerative changes may be profound enough to render an athlete at risk for recurrent burners. Levitz et al.[7] reported that 87% (48 of 55) of collegiate and professional football players sustaining concurrent extension-compression burners had evidence of disk degeneration on MRI.

Degenerative changes superimposed on a developmentally narrow foramen are expected to further increase the risk of root injury.

Meyer et al.[9] have noted that collegiate athletes demonstrating cervical stenosis have approximately a threefold increased risk of sustaining an extension-compression burner compared with nonstenotic controls. Contact athletes sustaining recurrent extension-compression burners who demonstrate cervical canal or foraminal stenosis, or both, would be expected to derive benefit from means to limit cervical compression, extension, and lateral deviation—all mechanisms that narrow foraminal dimensions. Thus, the rationale for use of neck rolls and collars that may limit lateral deviation and extension and blocking/tackling techniques that avoid cervical compression appears plausible. The efficacy of such means in averting the burner syndrome, however, is beyond the scope of this paper.

CONCLUSIONS

We concluded from this study that 1) scholastic athletes found to have cervical canal stenosis are at increased risk of sustaining the burner phenomenon, 2) the foramen/vertebral body ratio is an easily reproducible and reliable means of assessing foraminal dimensions from oblique radiographs and controls for magnification and rotation, and 3) foraminal stenosis, like cervical canal stenosis, is associated with the burner phenomenon and may more directly characterize the zone of injury for the extension-compression burner.

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