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Assessment Of The Diagnostic Value Of Magnetic Resonance Imaging Derived Space Available For The Cord In Predicting The Risk Of Sub-axial Cervical Spinal Cord Injury.

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Abstract

Space available for the spinal cord (SAC) is a measure of cord functional reserves. Reduction in SAC value may predispose to cord injury. This study assessed the accuracy of MRI derived SAC in predicting the risk of spinal cord injury by comparing the subaxial cervical spine SAC values obtained in asymptomatic Nigerians and those with traumatic cervical spine cord injury (CSCI). Prospective, cross-sectional MRI-based study of selected 100 consenting asymptomatic adults and 88 CSCI patients done in Memfys Hospital, Enugu Nigeria from 2012 to 2017. SAC was calculated by subtracting disc level midsagittal cord dimension from corresponding level spinal canal dimension. Age range was between 21 to 50yrs. Data was analyzed using inferential and descriptive statistics. Mean SAC was used in calculating the sensitivity and NPV for SCI at each level. Average SAC value for each disc level for the asymptomatic and those with CSCI respectively were: C3/4 (4.9 + 1.2mm, 2.5 +/-1.7 mm), C4/5 (4.5+/-1.0mm, 2.2+/-1.4mm), C5/6 (4.7+/-1.0mm, 2.3+/-1.6mm), C6/7 (5.1+/-1.1mm, 2.7+/-1.9mm), C7/T1 (5.7 +/-1.2mm, 4.2+/-1.9mm). P-values were <0.05 especially at C4/5 and C5/6. Frequencies of cord injury level were: 43.2% (C5/6), 28.4% (C4/5), 17.1% (C6/7), 5.7% (C3/4), 3.4% (C7/T1), and 2.2% (C2/3). MRI derived SAC has a sensitivity of 93% and NPV of 90% in predicting an individual's risk of SCI. SAC has a high sensitivity and NPV and will be a good screening tool in predicting the risk of subaxial CSCI. SAC is significantly lower in the CSCI group especially at C4/5 and C5/6 levels.

Key words: SAC, Asymptomatic Nigerians, Cervical cord injury, Sensitivity, Negative predictive value.

INTRODUCTION

Acute cervical spinal cord injury (CSCI) can occur following trauma as a result of cervical spinal canal stenosis Previously, indirect canal stenosis indicators like plain radiograph and Computed Tomography (CT) scan derived Torg-Pavlov ratio (TPR) and spinal canal diameter were commonly used to assess cervical spinal canal stenosis However, these were associated with low sensitivity and negative predictive values.

The space available for the spinal cord (SAC) is a measure of spinal cord functional reserves The magnetic resonance imaging (MRI) derived SAC has been argued to be a reliable canal stenosis indicator However, the clinical relevance of SAC for predicting individuals at significant anatomical risk for sub-axial CSCI has not been fully investigated especially in the study environment.

This study aims to determine the sensitivity and negative predictive value of SAC as a screening tool for predicting radiological risk of sub-axial cervical spine injury among asymptomatic Nigerian adults. The study tested the hypotheses that people with traumatic CSCI have significant difference in the values of SAC when compared with asymptomatic Nigerians.

MATERIALS AND METHODS

This study was a prospective, cross-sectional MRI-based study involving adult Nigerians aged between 21 and 50 years that were stratified into two groups. One group was made of 88 patients being managed for CSCI that were serially recruited. The other group consisted of 100 consenting asymptomatic that were randomly selected (control group). The study was carried out at Memfys Hospital for Neurosurgery Enugu, Nigeria and spanned from years 2012 to 2017. Approval for this study was granted by the Institution's local ethics committee.

This study excluded spinal cord injured patients with spine fractures from CT scan or plain radiographs, patients with vertebral body listhesis or evidence of instability, significant cord oedema, penetrating or gunshot spine injury, individuals with previous cervical spine surgeries, non-Nigerians, individuals that participate in contact sport activities, individuals with symptoms referable to the cervical spine or spinal cord prior to CSCI or MRI scan and those with congenital deformities that may predispose to congenital canal stenosis.

Measurements were taken from mid-sagittal T2-weighted MR images of the cervical spine at disc level in neutral position from the C3/4 to the C7/T1 with BASDA 0.35T MRI machine and recorded to the nearest 0.1mm. Mid-sagittal disc-level spinal canal dimension A) was taken as well as corresponding level spinal cord dimension (B). SAC was calculated as A-B. (See figure 1).

Data was analyzed using both inferential and descriptive statistics in line with the objectives of the study, aided by the SPSS version 21.0. The derived mean-SAC was used in calculating the sensitivity and NPV for CSCI at each disc level.

Figure 1. T2-weighted magnetic resonance imaging of the midsagittal cervical spine with illustration of measurements obtained. (SAC=A-B)

RESULT

Table 1 analysed the demographic characteristics of the two groups.

Table 1. Patient's demographic characteristics

Characteristics	CSCI Group (n = 88)	Control Group (n = 100)
Sex		
Male	68	50
Female	20	50
Ratio	4.2:1	1.1:1
Age (Years)		
Median	36.0	36.5
Mean	36.4	36.4
Range	21-50	21-50

SAC value for each disc level for the asymptomatic and those with CSCI respectively were: C3/4 (4.9 + 1.2mm, 2.5 +/-1.7 mm) P=0.0001, C4/5 (4.5+/-1.0mm, 2.2+/-1.4mm) P=0.0001, C5/6 (4.7+/-1.0mm, 2.3+/-1.6mm) P=0.0001, C6/7 (5.1+/-1.1mm, 2.7+/-1.9mm) P=0.0001, C7/T1 (5.7 +/-1.2mm, 4.2+/-1.9mm) P=0.001. (Table 2).

Table 2: Compares SAC at each subaxial cervical spine between control and CSCI groups

Disc Levels	Mean SAC (mm) CSCI	Mean SAC(mm) Control	Partial eta squared	P value
C3/4	2.5 ± 1.7	4.9 ± 1.2	0.412	0.0001
C4/5	2.2 ± 1.4	4.5 ± 1.0	0.488	0.0001
C5/6	2.3 ± 1.6	4.7 ± 1.0	0.435	0.0001
C6/7	2.7 ± 1.9	5.1 ± 1.1	0.371	0.0001
C7/T1	4.2 ± 1.9	5.7 ± 1.2	0.187	0.001

SAC =(space available for the cord),
CSCI= (cervical spinal cord injury)

Frequencies of cord injury level were 43.2% (C5/6), 28.4% (C4/5), 17.1% (C6/7), 5.7% (C3/4), 3.4% (C7/T1), and 2.2% (C2/3). (See figure 2).

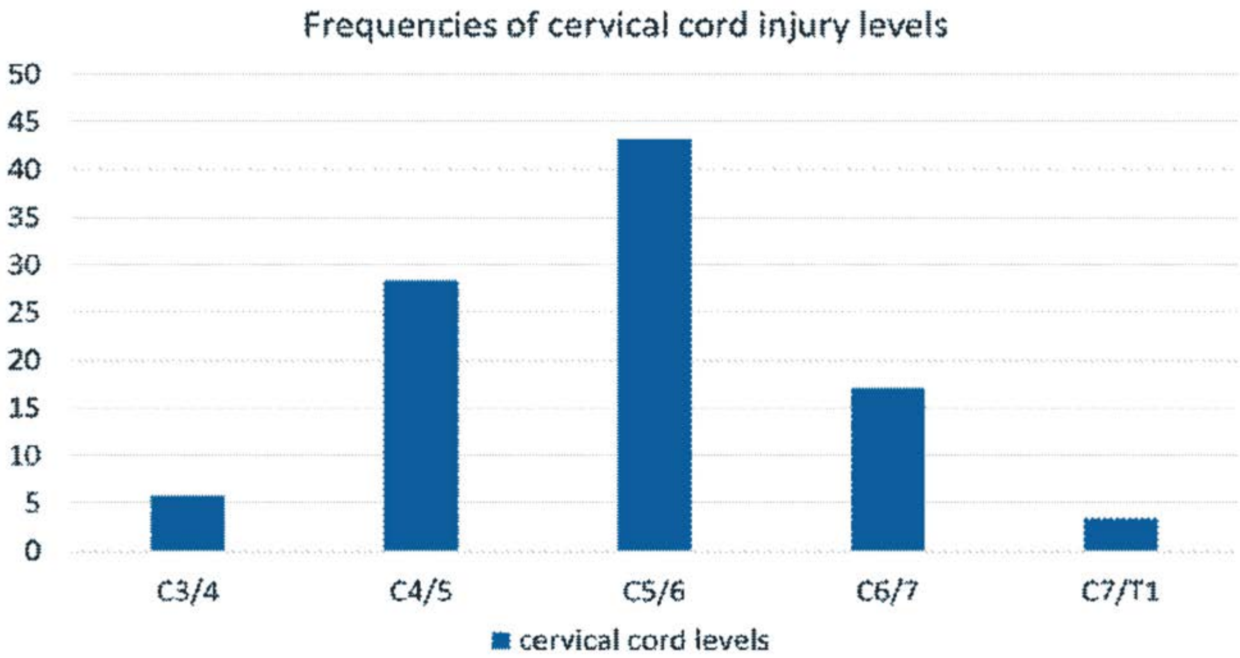

Figure 2. Frequencies of cervical cord injury levels in patients with CSCI

MRI derived mean SAC has a sensitivity of 93% and NPV of 90% in predicting an individual's risk of SCI across all subaxial cervical spinal cord levels (Table 3). The specificity of mean SAC in predicting the risk of spinal cord injury is 78% and the positive predictive value is 81%. (Table 3)

Table 3: Effectiveness of mean SAC as critical SAC value in predicting risk of CSCI following trauma to the cervical spine

Critical mean SAC value for all disc levels (mm)	Sensitivity (%)	NPV (%)	PPV (%)	Specificity (%)
4.98	93	90	81	78

SAC= space available for the cord
NPV= negative predictive value
PPV=positive predictive value
CSCI=cervical spinal cord injury

The sensitivity of mean SAC was 94% at C3/4, 98% at C4/5, 95% at C5/6, 89% at C6/7 (Table 4). The NPV of SAC was highest at C4/5 (95%) followed by C5/6 (92%), C3/4 (91%) and C6/7 (84%) (Table 4).

Table 4: Effectiveness of mean SAC size at each disc level as critical SAC value in predicting risk of CSCI following trauma to the cervical spine

Disc level	Disc level critical mean SAC value (mm)	Sensitivity (%)	NPV (%)	PPV (%)	Specificity (%)
C3/4	4.9	94	91	86	80
C4/5	4.5	98	95	81	76
C5/6	4.7	95	92	78	73
C6/7	5.1	89	84	69	66
C7/T1	5.7	78	76	66	60

SAC= space available for the cord
NPV= negative predictive value
PPV=positive predictive value
CSCI=cervical spinal cord injury

DISCUSSION

This study was designed to assess the sensitivity of MRI-derived SAC as a screening tool to predict the risk of subaxial cervical spine injury among the asymptomatic individuals. Patients with spinal cord injury were observed to have significantly smaller values of SAC when compared with the asymptomatic individuals. Therefore this finding affirms that when every other dynamic factor is excluded, the status of SAC correlates with the anatomical risk of spinal cord injury. This finding is especially marked at C4/5 and C5/6 levels. From this study, the spinal cord levels mostly exposed to the risk of spinal cord injury were the C4/5 and C5/6. Incidentally these levels have more marked differences in the values of SAC obtained between the spinal cord injury group and the normal individuals.

Overall sensitivity and negative predictive value of SAC as a screening tool for predicting the risk of cervical spinal cord injury was high in this study. This means that SAC has high probability of detection of individuals who are truly at risk of cervical spinal cord injury in 93-98% of the cases and can reliably predict the absence of this risk in more than 90% of the cases. From other studies done previously that analysed the usefulness of other indirect canal stenosis indicators like the Pavlov ratio and the midsagittal spinal canal dimension in predicting the risk of SCI, the results were rather poor. Despite these relatively weak results, these measures are still relied upon by many clinicians and sports physicians in screening for individuals at risk of cord injury and chronic stingers. For instance, the sensitivity and NPV of Pavlov ratio in predicting the risk of cervical SCI was 69% and 76% respectively . Also, the sensitivity and NPV of the midsagittal spinal canal diameter in predicting the risk of cervical spinal cord injury was 75% and 85% respectively . This is because canal narrowing caused by soft tissue cannot be assessed by these radiologic assessments tools. Additionally, the measurements were based on the values obtained at the mid-vertebral body levels instead of the disc level measurements which actually are the region where most degenerative changes will occur.

This study has helped to affirm the superiority of MRI derived SAC in predicting the risk of CSCI and therefore that SAC is a reliable tool for screening the asymptomatic individuals presumed to be at significant risk of spinal cord injury. SAC is a direct canal stenosis indicator which is also capable of identifying spinal cord with subtle asymptomatic pathologies since MRI is the only imaging modality that can directly and reliably investigate the dimension and status of the spinal cord. On the other hand, the relatively low specificity and positive predictive value of SAC in this study emphasizes the weakness of this as a diagnostic tool in those asymptomatic individuals. It should also be understood that SAC is intended to be a screening investigation for the asymptomatic individuals at risk of CSI and does not by itself diagnose cervical spine injury. Furthermore, a prior knowledge of SAC will not also be useful in predicting prognosis after spinal cord injury.

From sub-axial spine level analysis, the highest sensitivity and NPV of SAC were observed at the C4/5 with as high as 98% sensitivity and the C5/6 level with sensitivity of 95%. In same vein, this study observed the highest risk of spinal cord injury to be around the C4/5 and C5/6 levels. This further lays credence that the SAC derived values are very likely to be very useful in screening individuals for the risk of CSI especially at these levels that are known for high risk of CSI with very high reliability.

A major argument will be the cost benefit impact of the MRI derived SAC as a screening investigation. The major point to note is that MRI is the only modality that can directly image and demonstrate the spinal cord and discs and other soft tissue pathologies reliably, unlike the indirect stenosis measures like Pavlov ratio that do not take into account soft tissue contributions to spinal canal stenosis. In addition, MRI based investigations will also be more reliable and useful for collateral checks for subtle pathologies of the spinal cord. Therefore these indirect screening tools are somehow flawed with low sensitivity and NPV and may underestimate the level of risk for an individual. This study however advocates that for the purpose of screening, these SAC measurements should be obtained at the disc levels instead of the traditional mid-vertebral body levels in order to have more reliable picture of the level of risk of an individual.

One challenge with this study is that getting a representative screening cut-off point will vary from one region to another since the value of SAC has been shown to be influenced by race . It should also be understood that SAC based screening with its high sensitivity is not a substitute for other measures like driving regulations and other safety rules that are already institutionalized in some developed countries.

Finally, cervical spinal cord injury is a life threatening disease and early identification of individuals at risk may be a helpful primary prevention strategy especially in environments with significant risk of cord injury. Early identification of people with significant risk through reliable screening tools like SAC will enhance compliance with clinical and radiological surveillance measures aimed at early intervention when indicated based on evidence from follow-up of these individuals at significant risk. Nigeria has a great need for a reliable screening method for CSI considering the high prevalence of CSI

CONCLUSION

SAC is a good tool for predicting the risk of sub-axial cervical spinal cord injury because it has a very high sensitivity and NPV. The SAC is significantly lower in the group of patients that suffered cervical spinal cord injury and this may be the anatomical basis of cord injury in these individuals following trauma. The C4/5 and C5/6 levels have the most significant difference in SAC between the asymptomatic individuals and patients with cervical spinal cord injury and this may explain the high occurrence of traumatic cord injury recorded at these levels.

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