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Effect Of Age On The Space Available For The Cervical Spinal Cord (SAC) Of Asymptomatic Adult Nigerians

Ndubuisi CA*, Ohaegbulam SC, Mezue WC

Department of Neurosurgery, Memfys Hospital for Neurosurgery, Enugu, Nigeria

***Author for Correspondence:** chikandu@yahoo.com

Abstract

Frequency and burden of care of spinal cord injury (SCI) is high in Nigeria. Efforts should be channelled at identification of asymptomatic individuals at risk as a form of primary prevention strategy. This study analysed the age-adjusted space available for the spinal cord (SAC) values to identify age groups with critical drop in SAC values that suggest higher anatomical predisposition to SCI. This would serve as screening tool to predict risk of trauma or degenerative disease induced SCI from compromised CSF cushion. The study is a T1Wi MRI-based prospective, cross-sectional study of 100 randomly selected asymptomatic adults aged 21-50 years. SAC was calculated by subtracting disc level mid-sagittal spinal cord dimension (C) from corresponding level spinal canal dimension (S). The result revealed that the Mean-SAC for all age groups was 4.9±0.23mm. Age adjusted SAC value varied from 5.40±0.38mm (20-25 years) to 4.61±0.77mm (41-45 years) and 3.49±0.39mm (46-50 years). At C3/4 SAC was 5.54mm (21-25years) and 4.14(41-45years), 3.42mm (46-50years). (P=0.0001). At C4/5 SAC was 4.89mm (21-25years), 4.31mm (41-45years) and 3.42mm (46-50years). (P=0.015). At C5/6 SAC was 4.98mm (21-25years), 4.30mm (41-45years) and 2.97mm (46-50years). (P=0.0001). At C6/7 SAC was 5.42mm (21-25years), 4.89mm (41-45years) and 3.67mm(46-50years). (P=0.001). Pairwise comparison revealed significant drop in SAC values obtained in the 41-50 years group across all disc levels when compared with SAC value obtained from 20-40 years.(P=0.0001). Effect of age was mostly at C3/4 to C5/6 levels. This study has revealed that the study population had very small space available for the cervical spinal cord when compared with other populations and with further significant drop in SAC after 45 years of age. Small SAC values with advancing age suggest increased risk of cervical cord injury and need to utilize the magnetic resonance imaging derived SAC as screening strategy to assess the level of risk for spinal cord injury among the asymptomatic high risk individuals.

Key words: Disc level SAC; Asymptomatic; MRI Screening; C-spine, Nigeria

INTRODUCTION

The challenge of spinal cord injury (SCI) management is a global problem with significant burden on patients' quality of life and health care system (Dryden et al. 2003; McCammon et al. 2011). The incidence, prevalence and known predisposing factors of SCIs differ from one region of the world to another and therefore preventive and management strategies need to be tailored to regional trends (Singh et al. 2014). Reduced space available for the spinal cord (SAC) decreases the ability of cerebrospinal fluid (CSF) to absorb kinetic forces directed at the spine (Nouri et al. 2017). Therefore, these individuals are at a substantially higher risk of traumatic SCI. Efforts should therefore be channelled towards the early identification of asymptomatic individuals with such a significant risk of spinal cord injury as a result of a compromised SAC as a form of primary prevention strategy.

The frequency of cervical spinal cord injury is particularly very high in Nigeria (Emejulu et al. 2009) with substantial risk of high severity, morbidity, mortality (Obalum et al. 2009) and financial burden to the families estimated at USD 11,428, representing between 6-230% of the patient's annual income (Kawu et al. 2011). This justifies further research channelled towards primary preventive measures in this environment.

There is some evidence that the study population has significant anatomical predispositions to spinal cord injury (Ndubuisi et al. 2017). The possibility raised in some studies (Shingu et al. 1994) that there is age group with relative higher risk of this anatomical predisposition also implies that there may be benefit from prophylactic cervical spine MRI screening for individuals with significant occupational risk for SCI.

This study aims to carry out the age-adjusted analysis of the values of SAC in order to identify age groups with significant drop in SAC values to suggest higher anatomical predisposition to SCI in Nigeria.

MATERIAL AND METHODS

A prospective, MRI-based, cross-sectional study was carried out in a tertiary hospital in Nigeria from 2012-2014. Following ethical approval, the study recruited 100 randomly selected asymptomatic Nigerians between 21 years and 50 years old who volunteered. T1Wi scan measurements were obtained at the disc levels from C3/4 to C7/T1 and used in this study. T2Wi images were also obtained to help in excluding any cervical spine pathology that would not be apparent from the T1Wi scan. The study excluded non-Nigerians, individuals with congenital deformities that may suggest predisposition to canal stenosis such as spina bifida, previous cervical spine infection or surgeries. All patients signed informed consent before participating in the study. MRI images were obtained with 0.35T machine using the standard protocol. After the mid-sagittal T1Wi was acquired, disc-level spinal canal dimension (S) and the corresponding level spinal cord dimension (C) were measured three times before taking an average in millimetres. SAC was calculated as S-C. (See figure 1).

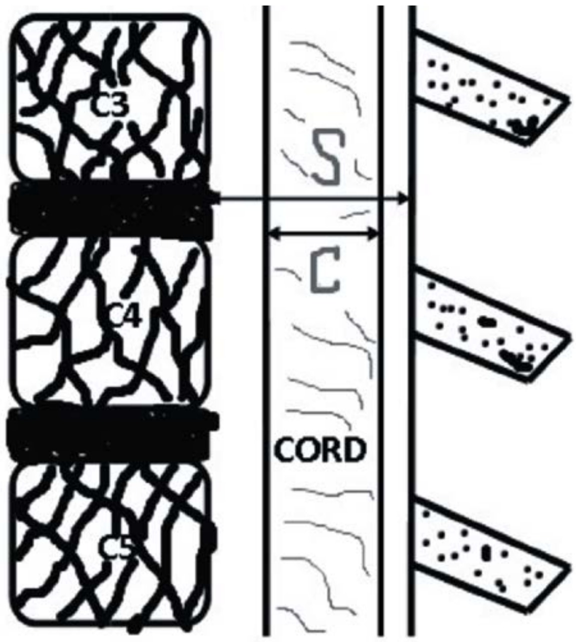

Figure 1: Sketch illustration of the disc level mid-sagittal spinal canal (S) and spinal cord (C) measurements taken from the T1Wi MRI. SAC was calculated as S-C

Data was analysed using mean, Pearson correlation, ANOVA, pairwise comparison (least significant difference test) and aided by the SPSS version 17. A p-value of ≤ 0.05 was considered significant.

RESULT

The mean SAC measured across all age groups was 4.9±0.23mm. However, the age sub-group analysis of SAC value for the different age groups was summarized in Table 1.

Table 1. Age group analysis of the values of SAC

Age (years)	Mean (mm)	Std. Deviation	Minimum (mm)	Maximum (mm)
20 - 25	5.40±0.38	0.75596	4.32	7.04
26 - 30	5.12±0.51	0.95650	3.90	6.96
31 - 35	5.32±0.47	0.98025	3.56	7.66
36 - 40	5.16±0.39	0.76340	3.66	6.42
41 - 45	4.61±0.77	1.49855	2.68	4.92
46 - 50	3.49±0.39	0.64128	2.32	6.88
Mean SAC	4.92±0.23	1.13635		

Table 2 analyzed the values of SAC at each disc levels with different age groups. This revealed a sharp drop after the fourth decade of life, with P-values of 0.0001 (C3/4), 0.015 (C4/5), 0.0001(C5/6), 0.001(C6/7) and 0.0001 (C7/T1).

Table 2: Sub-axial cervical spine disc level values of SAC for different age ranges.

Levels	Age (years)							
(mm)	20-25	26-30	31-35	36-40	41-45	46-50	F	P value
SAC3/4	5.54	.28	5.54	5.16	4.14	3.42	8.134	.0001
SAC4/5	4.89	4.95	4.76	4.52	4.31	3.42	2.993	.015
SAC5/6	4.98	4.84	4.96	4.86	4.30	2.97	5.198	.0001
SAC6/7	5.42	4.86	5.28	5.33	4.89	3.67	4.754	.001
SAC7/T1	6.16	5.64	6.05	5.94	5.39	3.99	5.778	.0001

Overall pair wise comparison of the effect of age groups on SAC using the least significance difference revealed a hypothesis df of 25.0 with Wilks' Lambda F=2.316 (P=0.0001). However, at subgroup analysis, the Pairwise comparison revealed significant difference when age group 41-50 years was compared with the 20-40 years age group with a P-value of 0.0001 at C3/4 level, 0.015 to 0.001 at C4/5 level, 0.0001 at C5/6 level and 0.001 at C6/7 level (Table 3).

Table 3: Pair wise Comparisons of age groups

Level	Age pairs (years)		Mean Diff.	P value
SAC3/4	20 - 30	31 - 40	.059	.833
		41 - 50	1.591*	.000
	31 - 40	41 - 50	1.531*	.000
SAC4/5	20 - 30	31 - 40	.268	.354
		41 - 50	1.003*	.001
	31 40	41 50	.736*	.015
SAC5/6	20 - 30	31 - 40	.001	.998
		41 - 50	1.202*	.000
	31 - 40	41 - 50	1.201*	.000
SAC6/7	20 - 30	31 - 40	-.147	.597
		41 - 50	.815	.006
	31 40	41 50	.962	.001
SAC7/T1	20 - 30	31 - 40	-.080	.809
		41 - 50	1.149*	.001
	31 - 40	41 - 50	1.228*	.000

Wilks' Lambda F=2.316, Hypothesis df=25.0, P=0.0001

The negative correlation between age of an individual and SAC was significant at C3/4 (P=0.0001), C4/5 (P=0.008), C5/6 (P=0.006), and C6/7 (P=0.049). (Table 4)

Table 4: Correlation between age and SAC at each sub-axial spine level.

		Correlations				
		SAC3/4	SAC4/5	SAC5/6	SAC6/7	SAC7/T1
Age	Pearson Correlation	-.446**	-.266**	-.272**	-.197*	-.271**
	Sig. (2-tailed)	.000	.008	.006	.049	.006

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The negative correlation between age of an individual and SAC was significant at C3/4 (P=0.0001), C4/5 (P=0.008), C5/6 (P=0.006), and C6/7 (P=0.049). (Table 4)

DISCUSSION

SAC is the CSF filled space around the cord and is expected to provide cushion to the cord against injuries. The SAC is a critical cervical canal stenosis index which enables discrimination between patients at risk for cervical SCI and those not at risk with sensitivity and specificity greater than 90% (Rüegg et al. 2015) In a previous study by Nduduisi et al. (2017) asymptomatic individuals from this study population have a small mean SAC value unlike many other regions of the world. Therefore, the study population is predisposed to higher risk of spinal cord injury by the virtue of this underlying anatomical predisposition and this may partly explain the high proportion of spinal cord injury among the study population. The MRI derived SAC may predict the level of risk of predisposition of an individual to post-traumatic and degenerative cervical myelopathy (Rüegg et al. 2015). (Figure 2).

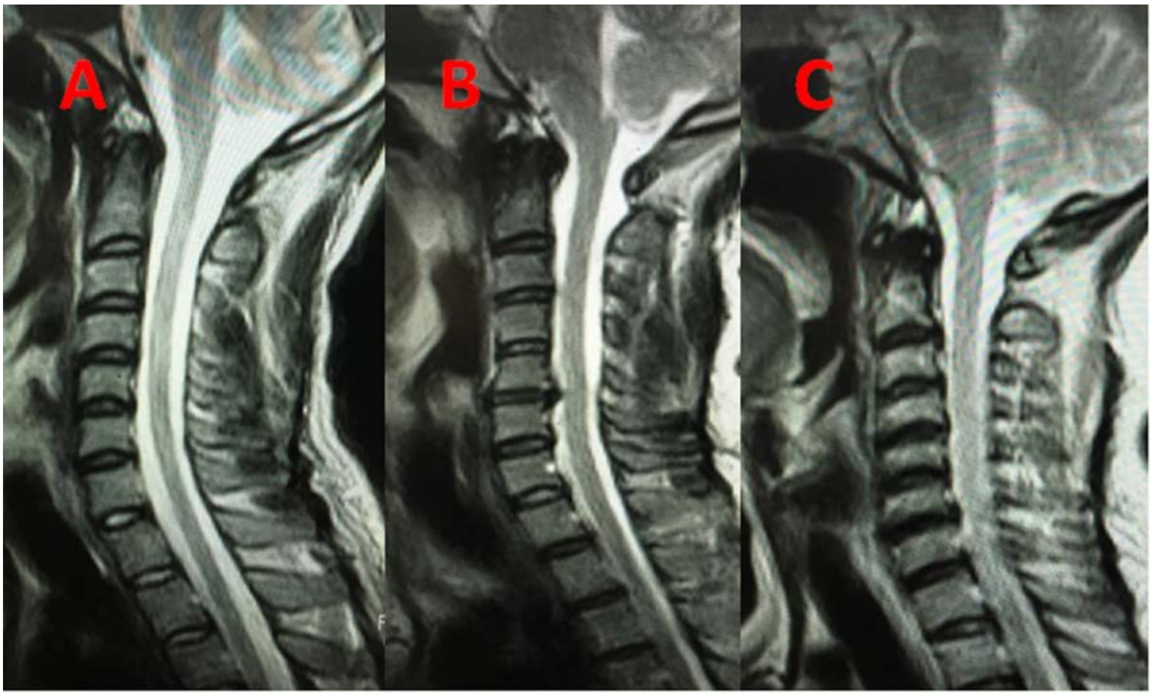

Figure 2: T2W images of patients in the third decade of life showing different degrees of disc level degenerative disease causing spinal canal stenosis and reduction in the SAC at the disc levels.

Image A revealed a near normal cervical spine without significant compromise of the disc-level SAC. Image B revealed focal narrowing of SAC at C5/6 level while image C revealed more advanced compromise of SAC involving all the sub-axial cervical spine levels. A cord-canal mismatch as determined by spinal cord occupation ratio of ≥ 70% on midsagittal imaging has been shown to increase the risk of spinal cord injury in some study populations. (Nouri et al. 2017)

Age also has a definite effect on SAC as revealed in this study. There is a significant negative correlation between age and SAC in asymptomatic individuals at each sub-axial spine level ($P<0.05$, table 4). The impact of age is most significant after the fourth decade of life and this reduction in SAC will further worsen the risk to the cord, especially at C3/4 to C5/6 levels. This trend has also been observed in the Japanese population where a large proportion of the spinal cord injured patients are over the age of 50 years (Shingu et al. 1994) This study has brought to fore, the relatively younger age at which asymptomatic individuals in the study population the risk of sub-axial spinal cord injury is increased in the study environment among asymptomatic individuals. The finding in this study is consistent with the degenerative changes in the spine with high prevalence of congenital canal stenosis which will narrow the SAC (Fehlings et al. 2013). Therefore, advancing age is a risk factor for spinal cord injury in this study population. Furthermore, associated comorbidities in the elderly like diabetes mellitus, poorly controlled hypertension and hypercholesterolemia may cause microangiopathy which may further worsen outcome of spinal cord injury.

As age advances therefore, asymptomatic individuals with previously unidentified pre-existing tight SAC may develop significant SCI even following trivial trauma, road traffic accidents, whiplash injury or during positioning of the patients for general anaesthesia and surgery. (Matveeva et al. 2012, Ndubuisi et al. 2017b) This risk will be particularly higher among asymptomatic individuals that participate in active high risk unsupervised professional and non-professional occupational and sporting activities, the military and construction workers.

In theory and in practice therefore, active high risk asymptomatic individuals with pre-existing small values of SAC are more likely with advancing age to have worse outcome following spinal cord injury and this risk may be reduced by prior knowledge of SAC of an individual. (Nouri et al. 2017) Prior knowledge of SAC through a screening Magnetic Resonance Imaging may help to advice these high risk asymptomatic individuals on their level of risk of cord injury.

SAC values affect the primary injury and are most amenable in primary prevention prevention. Awareness of pre-existing compromised SAC may enhance compliance with precautions aimed at prevention of spinal cord injury among individuals with high risk of exposure like artisans, military personnel, drivers and individuals involved in active contact sports and construction workers.

There are of course arguments around the cost benefits of MRI-based screening of cervical spine for individuals with higher risk of cord injury; however, an important question needs to be addressed in a study population with high burden of spinal cord injury. Although the argument of the relatively higher cost of MRI-based screening is understood (<USD300), there is need to compare this with the cost of short term management of spinal cord injury in Nigeria (>USD11, 000) (Kawu et al. 2011) with no guarantee of good outcome. The current approach of care relies on management of patients presenting with advanced symptoms but a paradigm shift to early identification of an individual at high risk through screening and subsequent follow-up may be a more viable alternative. There is also evidence that MRI is currently the only imaging modality that can reliably image the spinal cord and therefore help to calculate parameters like SAC which is a direct stenosis index for the spinal cord. (Presciutti et al. 2009; Aebli et al. 2013) The use of anatomical measurements like the SAC to determine at what critical value of these measurements the sub-axial cervical spinal cord would be at higher risks of damage following mechanical insults is therefore very useful in the study community.

The sudden further decrease in the SAC of these individuals after 45 years of age suggests that the individuals at this age range or younger exposed to high risk occupation or lifestyle may benefit from SAC- based screening for level of risk of spinal cord injury. Further studies will help to fine-tune SAC values approaching certain critical value that may be at the threshold that will be most effectively served by a properly organised community based sub-axial cervical spine screening awareness programme based on the expected level of occupational risk of each individual for spinal cord injury.

This strategy will improve the level of patient orientation and recognition of warning symptoms that should alert them to seek specialist care early enough. There is however need to further validate the results of this study using follow-up studies before such large scale screening programme can be adopted.

CONCLUSION

The study showed that there is negative correlation between age and SAC. Effect of age was mostly at C3/4 to C5/6 levels especially after 45 years of age. The study population had small SAC values compared to most parts of the world. Asymptomatic Nigerians had further significant drop in values of SAC after 45 years of age across all the sub-axial spine levels especially as low as 2.97mm at C5/6 level and 3.42mm at C3/4 and C4/5 levels. Small values of SAC suggest increased risk of cervical cord injury which may be part of the anatomical basis for the increased frequency of sub-axial cervical spinal cord injury in the study region.

This study recommends cervical spine MRI screening of high risk asymptomatic adults after 45 years of age or for younger people involved in high risk occupational and sporting activities with initial screening SAC values approaching this critical value observed among those above 45 years old. This will help to predict and monitor people with increased risk of post-traumatic or degenerative disease induced cervical SCI.

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REFERENCES

Aebli N, Rüegg TB, Wicki AG, Petrou N, Krebs J. (2013). Predicting the risk and severity of acute spinal cord injury after a minor trauma to the cervical spine. Spine J. 13:597–604.

Boden SD, McCowin PR, Davis DO, Dina TS, Mark AS, Wiesel S. (1990). Abnormal magnetic resonance scans of the cervical spine in asymptomatic subjects. A prospective investigation. J Bone Joint Surg Am. 72(8):1178-84.

Dryden DM, Saunders LD, Rowe BH, et al. (2003). The epidemiology of traumatic spinal cord injury in Alberta, Canada. Can J Neurol Sci. 30(2):113–121.

Emejulu JK, Ekweogwu C, Nottidge T. (2009). The burden of motorcycle-related neurotrauma in south-east Nigeria. J Clin Med Res. 1(1):13-7.

Fehlings MG, Tetreault LA, Wilson JR, Skelly AC. (2013). Cervical spondylotic myelopathy: current state of the art and future directions. Spine (Phila Pa 1976). 38(22 Suppl 1):S1–S8.

Igun GO, Obekpa OP, Ugwu BT, Nwadiaro HC. (1999). Spinal injuries in the Plateau State, Nigeria. East Afr Med J. 76:75-79.

Iwegbu CG. (1983). Traumatic paraplegia in Zaria, Nigeria: the case for a centre for injuries of the spine. Paraplegia. 21:81–5.

Kawu AA, Olawepo A, Salami AO, Kuranga SA, Abdulhameed S, Esenwah VC. (2011). A cost analysis of conservative management of spinal cord-injured patients in Nigeria. Spinal Cord. 49(11):1134-7.

Matveeva N, Lazarova D, Nakeva N, Zivadinovik J, Zafirova B. (2012). Cervical spinal canal measurements- indicators of spinal stenosis. Acta morphol. 9(1):20-3.

McCammon JR, Ethans K. (2011). Spinal cord injury in Manitoba: a provincial epidemiological study. J Spinal Cord Med. 34(1):6–10.

Ndubuisi CA, Mezue WC, Ohaegbulam SC. (2017). Space Available for the Cervical Spinal Cord of Asymptomatic Adult Nigerians. Korean Journal

Ndubuisi CA, Ohaegbulam SC, Mezue WC. (2017). Impact of Active Leisure (Non-Competitive) Contact Sports Activities on Space Available for Cord (SAC) of Sub-Axial Cervical Spine of Asymptomatic Adults. World Neurosurgery. 108:705-710.

Nouri A, Montejo J, Sun X, Virojanapa J, Kolb L, Abbed K, Cheng J. (2017). Cervical Cord-Canal Mismatch: A New Method for Identifying Predisposition to Spinal Cord Injury. 108:112-117.

Obalum DC, Giwa SO, Adekoya-Cole TO, Enweluzo GO. (2009) Profile of spinal injuries in Lagos, Nigeria. Spinal Cord. 47(2):134–7

Presciutti SM, DeLuca P, Marchetto P, Wilsey JT, Shaffrey C, Vaccaro AR. (2009). Mean subaxial space available for the cord index as a novel method of measuring cervical spine geometry to predict the chronic stinger syndrome in American football players. J Neurosurg Spine 11:264–271.

Rüegg TB, Wicki AG, Aebli A, Wisianowsky C, Krebs J. (2015). The diagnostic value of magnetic resonance imaging measurements for assessing cervical spinal canal stenosis. Journal of Neurosurgery Spine. 22(3):230-6

Shingu H, Ikata T, Katoh S, Akatsu T. (1994). Spinal cord injuries in Japan: a nationwide epidemiological survey in 1990. Paraplegia. 32(1):3–8.

Singh A, Tetreault L, Kalsi-Ryan S, Nouri A, Fehlings MG. (2014) Global prevalence and incidence of traumatic spinal cord injury. Clinical Epidemiology. 6:309-331.

Udosen A, Ikpeme A, Ngim N: (2007). A prospective study of spinal cord injury in the University of Calabar Teaching Hospital, Calabar, Nigeria. Internet J Orthop Surg. 5:1.