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Original Article

MR Morphometric Evaluation of Cervical Spinal Canal in Pakistani Population

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Abstract

Objective: To determine the morphometric determinants of cervical spinal canal and spinal cord in Pakistani population and to compare it with other populations and to evaluate gender differences in them.

Methods: This is a retrospective study and included 200 individuals of 19-75 years of age presenting to Radiology department for MRI of cervical spine. MRI study of cervical spine was done. Measurements were taken using sagittal T2 weighted images from C3 to C7 in midsagittal location.

Results: Males had a significantly larger average diameter of vertebral body. The Torg's ratio is higher in females. The average measurements of midsagittal diameter of spinal canal, spinal cord and space available for cord (SAC) did not show any significant gender differences.

Conclusion: It is concluded that MRI is more reliable imaging modality for morphometric analysis of cervical spine than x-rays.

Keywords: Cervical spine, Spinal cord, Torg's ratio.

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Introduction

A large adult population suffers from pain in neck region at some point in life which mostly radiates to upper limbs. In 2015, backache and neck pain were considered 4th among the leading causes of years lived with morbidity. In 2015, it was estimated that more than one third of a billion world population suffers from pain in neck region of greater than three months duration.[1] Stenosis of cervical spinal canal is often the cause. This condition is termed as narrowing of the spinal canal in which lies the spinal cord, its covering layers and nerve roots.[2] The spinal canal size is very important clinically especially in trauma and degeneration. Stenosis of cervical spinal canal is believed to be a predisposing factor for the development of spondylotic myelopathy of cervical region.[3,4]

In 1957, Payne EE and Spillane JD performed a study taking cervical spine lateral radiographs to calculate antero-posterior diameter of cervical spinal canal.[5] Review of literature shows that many studies have been performed on different populations showing variations in spinal canal morphometric values. These variations are largely due to magnification factors associated with plain radiographs apart from genetic and hormonal factors. In order to overcome this problem, Parlov and Torg devised a ratio called as Torg's/ Parlov's ratio to determine spinal canal stenosis. This ratio is calculated by dividing the midsagittal diameter of cervical spinal canal by midsagittal vertebral body diameter.[6,7]

Many imaging modalities are available for evaluating patients presenting with neck pain. Plain radiography is the primary diagnostic modality used to evaluate patients presenting with spinal disease.[8,9] Although plain x rays can very well delineate the osseous structures like vertebral body and spinal canal, but it fails to provide information regarding soft tissues which are also an important contributor to spinal canal stenosis. MRI overcomes this problem as it can accurately measure the spinal canal, as well as spinal cord and also provides information regarding soft tissues. Thus MRI can not only calculate Torg's ratio and other morphometric determinants, but can also calculate space available for cord (SAC) which is determined by subtracting spinal cord diameter from sagittal diameter of spinal canal.[10,11]

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The aim of this study is to determine the morphometric determinants of cervical spinal canal and spinal cord in Pakistani population and to compare it with other populations and to evaluate gender differences in these determinants.

Methods

This is a retrospective study and included 200 individuals (102 males and 98 females) of 19-75 years of age (average age 42.14 ± 12.1 years) who presented to Radiology department for MRI of cervical spine. Patients less than 18 years of age, with infectious, congenital or neoplastic spinal disorders were excluded. MRI study of cervical spine was done on 1.5 Tesla GE MRI machine. The MR protocol consisted of a sagittal T1-weighted fast spin-echo sequence (FSE) (repetition time(TR)/echo time(TE)- 427/10msec; section thickness-3 mm; field of view (FOV)-220 × 220mm; matrix-352×192), sagittal T2-weighted fast recovery fast spin-echo (FRFSE) sequence (3491/109.6; section thickness-3mm; intersection gap-0.5mm; FOV: 220 × 220; matrix 352 × 224), and an axial cube T2-weighted images (1277/92.6; section thickness-1.4 mm; intersection gap-0.7 mm; field of view -200 × 200 mm; matrix 288 × 288). All imaging was performed by a qualified radiographer and evaluated by a consultant radiologist. Measurements were taken using sagittal T2 weighted images from C3 to C7 in midsagittal location. The distances were taken in centimeters.

Figure 1: *Midsagittal T2 Weighted Image of Cervical Spinal Cord Showing;*
1, 4, 7, 9, 12: Mid sagittal diameter of vertebral bodies (C3-C7)
2, 5, 8, 10, 13: Mid sagittal diameter of spinal canal (C3-C7)
3, 6, 9, 11, 14: Mid sagittal diameter of spinal cord (C3-C7)

Results

All morphometric determinants were taken from C3-C7 vertebral levels in 200 individuals (102 males and 98 females) of 19-75 years of age (average age 42.14 ± 12.1 years.).

Mid Sagittal Vertebral Bodies Diameter:

Measurements were calculated for both males and females from C3- C7 vertebral levels (table 1). Mean and standard deviation was calculated for both genders. The average sagittal vertebral body diameter was 1.54 ± 0.18 for males and 1.38 ± 0.15 for females. Males had a larger diameter of vertebral body as than females with a p value of 0.043. The maximum average diameter of vertebral body was maximum at C6 vertebral level in both genders.

Midsagittal Spinal Canaldiameter

The midsagittal measurements of spinal canal diameter were taken from C3- C7 vertebral levels for both males and females (table 1). The average cervical spinal canal diameter was 1.16 ± 0.18 for males and 1.16 ± 0.15 for females. There was no statistical difference between the spinal canal diameter for males and females with p value of 0.21. The midsagittal diameter of spinal canal at C4 spinal level was less than measured at C3 spinal level; however it was maximum at C7 spinal level in both genders.

Midsagittal Spinal Cord Diameter:

The measurements were calculated from C3-C7 vertebral levels for both genders and are represented as mean ± standard deviation (table 1). The average cord diameter was 0.69 ± 0.21 for males and 0.66 ± 0.08 for females with no statistical difference between the two genders (p value 0.09). The cord diameter was maximum at C3 vertebral level in females and C4 vertebral levels in males.

Torg's Ratio:

Torg's ratio was calculated by dividing midsagittal spinal canal diameter by midsagittal vertebral body diameter from C3-C7 levels in both genders (table 1). The mean value of Torg's ratio was 0.84 ± 0.19 in males and 0.94 ± 0.19 in females. Females had a statistically higher Torg's ratio than males having a p value of 0.006 due to larger vertebral body diameter in males. (Figure 2,3)

Space Available For Cord (sac):

The values of SAC were calculated from C3-C7 verte-

bral levels for both males and females by subtracting midsagittal spinal cord diameter from midsagittal spinal canal diameter. The mean value of SAC was 0.47± 0.29 for males and 0.50 ± 0.15 for females with no statistically significant difference between the two genders (p value 0.150).

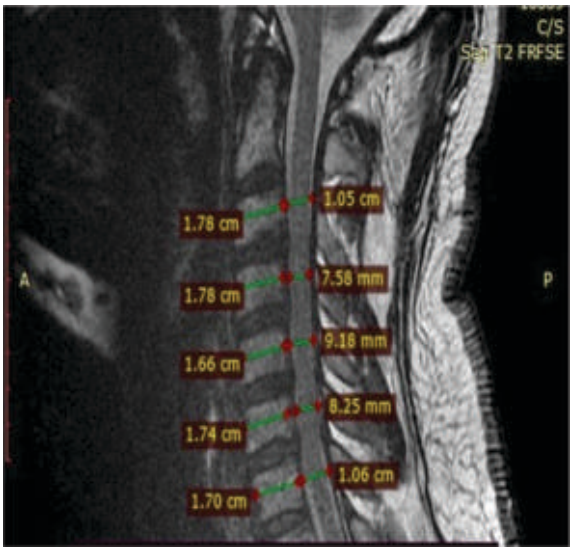

Figure 2: *Torg's Ratio Calculated at C3-C7 Cervical Spinal Level by Dividing Midsagittal Diameter of Cervical Spinal Canal by Midsagittal Vertebral Body Diameter at Each Level.*

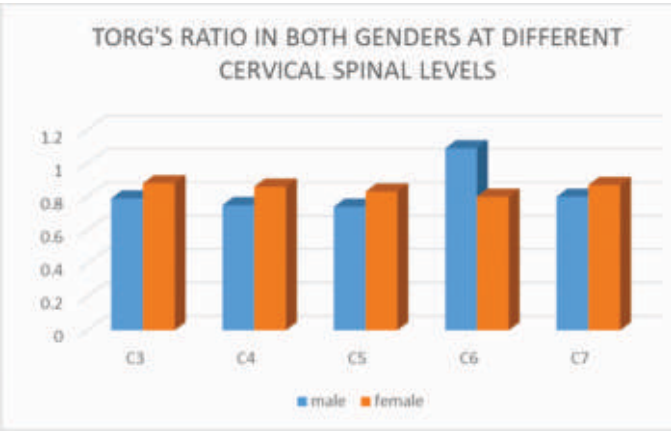

Figure 3: *Torg's Ratio in Both Genders at C3-C7 Cervical Spinal Levels.*

Discussion

Seven vertebrae constitute the cervical spine. The first two cervical vertebra are termed as atypical while C3-C7 comprise the typical cervical vertebra. The cervical spinal canal contains the cervical cord and nerve roots along with investing meninges and CSF. The space available in the spinal canal for spinal cord is essential for free movement of its contents. The size of spinal canal is fairly large in upper cervical region and decreases from C3 till C7. Hence, any condition that decreases the diameter of spinal canal particularly at C3-C7 level will result in abnormal pressure on spinal cord and nerve roots leading to neck pain. Many factors are responsible for variation in the size of the spina canal including mechanical, postural and genetic factors. Therefore it is seen that various studies of spinal canal show variations in different populations. The relationship between cervical spondylotic myelopathy and diameter of spinal canal was established by Payne et al. Many studies have been performed on the morphometry of cervical spine since then. It is seen that there are variation of 1-4mm in in the diameters of cervical vertebral bodies and spinal canal in these studies. These variations can be explained by the fact that many authors have used plain radiography to calculate these measurements. These variations can be attributed to radiographic and patient factors e.g. patient, build, focus to film distance (FFD) etc.[12] Therefore, in recent years MRI is most widely used for morphometric analysis to avoid such discrepancies.

Torg ratio was devised by Torg and Parlov in an attempt to eliminate the discrepancies occurring due to radiographic and subject factors, since the spinal canal and vertebral body diameter on plain radiographs are affected equally by magnification. Moreover it is independent of radiographic and subject factors like FFD and patient build etc. They proposed that a Torg's ratio <0.8 suggests

Table 1: *Mid sagittal diameters (MSD) of vertebral bodies, spinal canal, spinal cord, Torg's ratio and space available for cord (SAC) at C3-C5 cervical spinal levels.*

	MSD of vertebral body		MSD of spinal canal		MSD of spinal cord		Torg's ratio		SAC	
	M	F	M	F	M	F	M	F	M	F
C3	1.55	1.39	1.20	1.21	0.73	0.70	0.79	0.88	0.47	0.51
C4	1.53	1.37	1.13	1.16	0.78	0.69	0.75	0.86	0.35	0.47
C5	1.52	1.37	1.12	1.12	0.69	0.68	0.74	0.83	0.43	0.44
C6	1.57	1.40	1.13	1.11	0.65	0.64	1.09	1.23	0.49	0.46
C7	1.54	1.38	1.22	1.19	0.60	0.58	0.80	0.87	0.62	0.61
Mean ± SD	1.54±0.18	1.38± 0.15	1.16±0.18	1.16 ±0.15	0.69±0.21	0.66±0.08	0.84±0.19	0.94±0.19	0.47±0.29	0.50±0.15

spinal canal stenosis. The importance of Torg's ratio in spinal canal stenosis has considerably been evaluated by many researchers since then.[13,14,15] These studies have found that Torg's ratio is better than sagittal spinal canal diameter in diagnosing the severity of stenosis of spinal canal in cervical region. Although Torg et al and Parlov et al have found that the normal value of Torg's ratio is 1 in American population and is independent of gender variations. However many recent studies have shown that Torg's ratio differs not only in individuals of different ethnicity but also shows gender variations in the same population. It is seen that Torg's ratio is smaller in men than in women.[16,17] Similar results are found in present study showing that females had a higher Torg's ratio than men due smaller size of vertebral body in females than in males. (Figure 3)

The space available for cord (SAC) is another important parameter to determine the risk of neurological injury. It provides information regarding the functional reserve that is available for movement of spinal cord and changes occurring due to trauma, aging and inflammatory conditions.[21,22] Unlike Torg's ratio which depends more on sagittal vertebral body diameter, the SAC depends more on sagittal spinal canal diameter and shows less variability than Torg's ratio. Research has shown that a low value of SAC has increased risk of neurological injury of cervical spinal cord and its recurrence.[22] Individuals with less SAC are more at risk of developing spinal canal stenosis with lesser degree of pathological changes like facet joint arthrosis, osteophytes, disc herniation etc. Herzog RJ et al suggested that SAC is especially significant if Torg's ratio is <0.8 or the sagittal cervical spinal canal diameter is < 12.5mm in symptomatic individuals.[11]

Conclusion

It is concluded that MRI is more reliable imaging modality for morphometric analysis of cervical spine than plain radiography. The sagittal vertebral body diameter show gender variations and is more in males than in females resulting in high value of Torg's ratio in females. Thus Torg's ratio cannot be used as a reliable parameter for assessment of spinal canal stenosis as it may over diagnose cervical canal stenosis in males. On the other hand, sagittal diameter of spinal cord and spinal canal did not show any gender dimorphism, resulting in less variability in SAC values. It is also found that the value of Torg's ratio and SAC is smaller in our study as compared to other studies of this region.

Abbreviations

SAC: Space available for cord

MSD: Mid sagittal diameter

MRI: Magnetic resonance imaging

FSE: fast spin-echo sequence

TR: repetition time

TE: echo time

FOV: field of view

FRFSE: fast recovery fast spin-echo

Conflict of Interest: None

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Authors Contribution

M.K, R.R.: Conceptualization of Project,
M.K, R.R. K.R.: Data Collection
R.R, K.R.: Literature Search
K.R, S.M.R, H.M.: Statistical Analysis
S.M.R, H.M.: Drafting, Revision
M.K, R.R,S.M.R, H.M. . Writing of Manuscript