

Computed tomographic measurement of cervical pedicles for transpedicular fixation in a Malay population

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ABSTRACT

Purpose. To measure the cervical pedicles and assess the feasibility of transpedicular fixation in a Malay population.

Methods. 960 computed tomography (CT) scans of bilateral C2 to C7 pedicles of 80 Malays were compared. 22 men and 24 women aged <60 (mean, 37.3; range, 18–56) years were defined as young patients, whereas 18 men and 16 women aged ≥60 (mean, 63.9; range, 60–76) years as elderly patients. An inner diameter of <3.0 mm (85% of a 3.5-mm screw) was defined as ‘unfeasible’ and a medial or lateral wall thickness of <1.0 mm as ‘unsafe’ for cervical pedicle screw fixation.

Results. In the respective young versus elderly groups, the inner diameters ranged from 1.94 to 2.80 mm versus 2.51 to 3.37 mm in men, and from 1.52 to 2.31 mm versus 1.64 to 2.46 mm in women. Medial wall thickness ranged from 1.25 to 1.46 mm versus 1.13 to 1.48 mm in men, and from 1.28 to 1.72 mm versus 1.10 to 1.24 mm in women. Lateral wall thickness ranged

from 0.80 to 0.90 mm versus 0.66 to 0.88 mm in men, and from 0.85 to 0.99 mm versus 0.59 to 0.86 mm in women.

Conclusion. The cervical spine of Malays may not be adequate to accommodate a 3.5-mm pedicle screw for transpedicular fixation, as this procedure may risk adjacent vital structures.

Key words: cervical vertebrae; Malaysia; tomography, X-ray computed

INTRODUCTION

Cervical pedicular screw fixation is increasingly popular.^{1–4} Its clinical uses involving different methods have been reported.⁵ Nonetheless, morphological studies of Asian cervical pedicles are few and most measure the outer cortical diameter. The outer diameter of the pedicle does not ensure proper screw placement.^{5,6} Absence or narrowness of the pedicle medullary canal may result in screw insertion failure. Therefore, the inner diameter and wall thickness may provide a more accurate assessment for placement of

Table
The inner diameters and medial and lateral wall thicknesses of pedicles of 80 Malays

Level	Inner diameter (mm)		p value	Medial wall thickness (mm)		p value	Lateral wall thickness (mm)		p value
	Mean (SD)			Mean (SD)			Mean (SD)		
	Men	Women		Men	Women		Men	Women	
Patients aged <60 years									
C2	2.03 (0.50)	2.12 (0.76)	0.61	1.46 (0.29)	1.72 (0.51)	0.04	0.86 (0.30)	0.99 (0.15)	0.08
C3	1.94 (0.52)	1.70 (0.41)	0.09	1.25 (0.31)	1.44 (0.34)	0.06	0.81 (0.26)	0.93 (0.21)	0.10
C4	2.34 (0.35)	1.52 (0.45)	0.00	1.34 (0.38)	1.39 (0.18)	0.56	0.90 (0.26)	0.90 (0.22)	0.99
C5	2.41 (0.64)	1.65 (0.66)	0.00	1.41 (0.30)	1.28 (0.17)	0.07	0.89 (0.31)	0.85 (0.17)	0.66
C6	2.56 (0.68)	1.77 (0.68)	0.00	1.30 (0.28)	1.32 (0.18)	0.78	0.90 (0.29)	0.90 (0.19)	0.90
C7	2.80 (0.58)	2.31 (0.76)	0.02	1.30 (0.19)	1.30 (0.22)	0.89	0.80 (0.12)	0.88 (0.17)	0.07
Patients aged ≥60 years									
C2	2.51 (0.98)	2.26 (0.71)	0.42	1.48 (0.22)	1.19 (0.18)	0.00	0.85 (0.17)	0.74 (0.19)	0.08
C3	2.58 (0.86)	2.19 (0.59)	0.13	1.31 (0.24)	1.24 (0.10)	0.34	0.83 (0.15)	0.59 (0.11)	0.00
C4	2.52 (0.50)	1.64 (0.42)	0.00	1.41 (0.21)	1.23 (0.15)	0.01	0.88 (0.17)	0.67 (0.09)	0.00
C5	2.51 (0.50)	1.79 (0.45)	0.00	1.20 (0.20)	1.10 (0.05)	0.06	0.73 (0.20)	0.81 (0.16)	0.25
C6	2.77 (0.57)	1.98 (0.54)	0.00	1.13 (0.23)	1.13 (0.23)	0.96	0.74 (0.15)	0.86 (0.09)	0.01
C7	3.37 (0.40)	2.46 (0.86)	0.00	1.15 (0.16)	1.22 (0.25)	0.30	0.66 (0.18)	0.75 (0.14)	0.12

cervical pedicle screws.

Although transpedicular screw fixation of the lumbar and thoracic spine can be safely performed in Asian patients with minimal complications, cervical pedicle diameters of Asians are reportedly narrower, with thinner medial and lateral walls. The width and height of cervical pedicles of Singaporean Chinese were more than 20% smaller than those of Caucasians.⁷ Cervical transpedicular screw fixation in Asian populations therefore poses concerns, especially in elderly osteoporotic patients. Many reports were based on a limited number of cadavers aged >60 years.⁴⁻⁷ In this study we aimed to compare the morphology of cervical pedicles in young and elderly Malays.

MATERIALS AND METHODS

960 computed tomography (CT) scans of bilateral C2 to C7 pedicles of 80 Malays aged 18 to 76 years admitted between January 2005 and August 2005 were randomly selected from the registry. 22 men and 24 women aged <60 (mean, 37.3; range, 18–56) years were defined as young, whereas 18 men and 16 women aged ≥60 (mean, 63.9; range, 60–76) years as elderly.

The narrowest inner diameter and medial and lateral wall thickness of the pedicles were measured. An inner diameter of <3.0 mm (85% of a 3.5-mm screw) was defined as 'unfeasible' and a wall thickness of <1.0 mm as 'unsafe' for cervical pedicle screw fixation. Patients with cervical abnormalities

(e.g. fracture, infection, or tumour) were excluded. CT scan cuts were at 2.5-mm intervals, perpendicular to the spinal axis.⁸ All measurements were made by a single surgeon and analysed using independent *t*-test of the Statistical Package for the Social Sciences (version 11.0, Chicago [IL], US).

RESULTS

In men aged <60 years, the mean inner diameters ranged from 1.94 (standard deviation [SD], 0.52) mm in C3 to 2.80 (SD, 0.58) mm in C7. In women, corresponding means ranged from 1.52 (SD, 0.45) mm in C4 to 2.31 (SD, 0.76) mm in C7. These differences between genders were significant (C4–C6, *p*<0.01; C7, *p*<0.05). The mean medial wall thickness of men ranged from 1.25 (SD, 0.31) mm in C3 to 1.46 (SD, 0.29) mm in C2. In women, they ranged from 1.28 (SD, 0.17) mm in C5 to 1.72 (SD, 0.51) mm in C2. These differences between genders were not significant, except at C2 (*p*<0.05). The mean lateral wall thickness of men ranged from 0.80 (SD, 0.12) mm in C7 to 0.90 (SD, 0.29) mm in C6. In women, they ranged from 0.85 (SD, 0.17) mm in C5 to 0.99 (0.15) mm in C2. These differences between genders were not significant (Table).

In men aged ≥60 years, the mean inner diameters ranged from 2.51 (SD, 0.98) mm in C2 to 3.37 (SD, 0.40) mm in C7. In women, they ranged from 1.64 (SD, 0.42) mm in C4 to 2.46 (SD, 0.86) mm in C7. These differences between genders were significant (*P*<0.001). The mean medial wall thickness of men

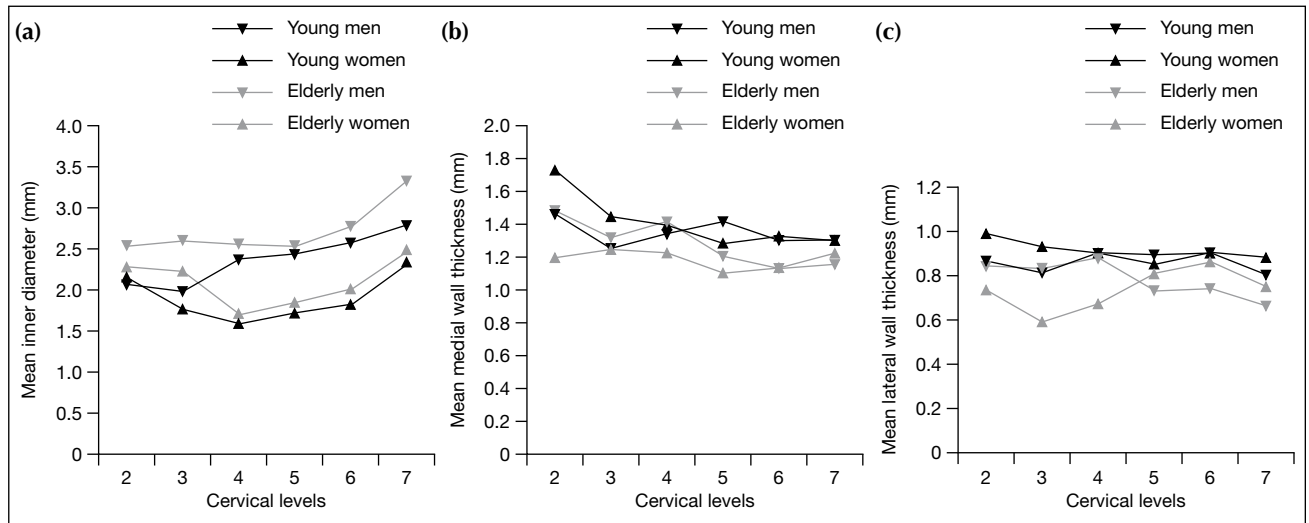


Figure Mean (a) inner diameter (b) medial wall thickness (c) lateral wall thickness of pedicles of 80 Malays.

ranged from 1.13 (SD, 0.23) mm in C6 to 1.48 (SD, 0.22) mm in C2. In women, they ranged from 1.10 (SD, 0.05) mm in C5 to 1.24 (SD, 0.10) mm in C3. These differences between genders were not significant, except at C2 ($p<0.001$) and C4 ($p<0.05$). The mean lateral wall thickness of men ranged from 0.66 (SD, 0.18) mm in C7 to 0.88 (SD, 0.17) mm in C4. In women, they ranged from 0.59 (SD, 0.11) mm in C3 to 0.86 (SD, 0.09) mm in C6. These differences between genders were not significant, except at C3, C4 ($p<0.001$) and C6 ($p<0.05$) [Table].

DISCUSSION

The narrowest point of the inner diameter (isthmus) and medial and lateral wall thickness of the pedicles affect the safety of transpedicular screw fixation. Such fixation is not recommended when the outer diameter of the pedicle is <4.5 mm, as a critical breach was observed in 12 to 18% of cadavers studied.⁵

The inner diameters for men were significantly wider than those of women (C4–C6, $p<0.01$; C7, $p<0.05$). Elderly patients had a significantly wider inner diameter than young patients at C3 (in both men and women) and C7 (in men). Nonetheless, the overall mean inner diameter was <3.0 mm (except at C7 in elderly men), which was still insufficient to accommodate a 3.5-mm screw, especially at C4 to C6 in women (diameter <2.0 mm) [Fig. a].

The inner diameters of the lumbar and thoracic pedicles may allow some expansion before breaking.⁹ However, in cervical pedicles, the inner diameters

are too small and the walls too thin to ensure safe expansion.^{9,10} Cortical breach of 3.0 mm may not be dangerous for the thoracic cord, but may be disastrous in the cervical region due to less free space.¹¹

Wall thickness determines the ability to contain the screws within the pedicle. Even in pedicles with an inner diameter of >3.5 mm, their wall thickness may not be sufficient to prevent perforation, especially in osteoporotic patients or if the screw is malpositioned. The medial wall was consistently thicker than the lateral wall at all levels in both genders and age groups, consistent with a study on non-Asians.¹² In patients <60 years old, the medial and lateral walls were generally thicker in women than men. On the contrary, they were thicker in men than women ≥ 60 years old at C2 to C4 levels. The thickness decreased in elderly patients due to age-related and post-menopausal osteoporosis.¹³ The decreases were significant in the medial walls of C2 to C6 (women) and C5 to C7 (men) and in lateral walls of C2, C3, C4, and C7 (women) and C6 to C7 (men) [Figs. b and c]. The decrease of wall thickness did not result in an increase in inner diameter. At all levels, the lateral wall thickness in both genders and age groups was <1.0 mm. The decrease in wall thickness in the elderly, especially in women increases the risk of a cortical breach¹³ and screw loosening.¹⁴ 17%⁶ and 40 to 48%⁵ incidences of pedicle wall perforations were reported in studies involving cadavers >60 years old.

The outer diameter of pedicles of Chinese Singaporeans ranged from 4.4 mm (C3) to 5.7 mm (C7),⁷ which was comparable to our findings. The

outer diameters (summation of the inner diameter and medial and lateral wall thickness) of their female subjects were smaller than those of males at all levels. Their cadaveric study and our radiological study did not support the use of transpedicular screws for fixation of the cervical spine in these populations.

Transpedicular cervical fixation using a 3.5-mm screw appears to pose a higher risk of a critical breach in Malays, especially in patients with osteoporosis and

thin pedicle walls (<1.0 mm).^{2,5} This study may help surgeons select more appropriate fixation techniques in Malays.

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