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Accuracy of cervical pedicle screw placement using patient-specific template guide system and risk factor analysis for screw perforation: CT- based evaluation of 437 screws

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Background: Previous studies demonstrated low perforation rate of 1.3-4.7% for cervical pedicle screws (CPS) inserted with template guided systems (TGS), however, there have been only small case studies and risk factors for perforation remain unknown.

Research question: Is the accuracy of CPS insertion using TGS really high, and are there any risk factors for perforation?

Design: Retrospective clinical evaluation of prospectively enrolled patients.

Methods: 80 consecutively enrolled patients (56 men and 24 women; age, 62.5±12.5years) who underwent CPS insertion using TGS were included. A total of 437 CPS were inserted with TGS. CT was used to evaluate CPS positions as well as radiographic parameters of CPS and vertebrae. Furthermore, comparisons of patient background factors and radiographic parameters were done between perforated screw group and non-perforated screw group.

Results: 413 (94.5%) screws were completely inside the pedicle, 22 (5.0%) screws deviated less than 2 mm and 2 (0.5%) screws deviated more than 2 mm and less than 4mm. Therefore, 435 (99.5%) screws were regarded as clinically acceptable. The perforation rate was highest in C4 (12.5%) (Table 1). There was no neurovascular injury. On average, TGS made CPS insertion point 3.1 mm medially and CPS insertion angle 16.4 degrees smaller than the anatomical pedicle axis. In comparisons between perforated screw group and non-perforated screw group, low height, low weight, low BMI, female, fellow surgeon, and narrow pedicle were considered risk factors for CPS perforation using TGS (Table 2).

Discussion: As previous studies, this study also showed high accuracy of CPS placement using TGS. Importantly, deviations of 2 mm or more were particularly rare, indicating high safety. TGS also enabled CPS trajectory with medial insertion points and small angle, reducing interference from the soft tissue during insertion. Pedicle diameter, patient body size, and surgeon's experience level may affect the accuracy.

Fig. 1

Table 1 Placement accuracy and direction of deviation of CPS

	Grade0	Grade1			Grade2		Total	Perforation rate
		Lateral	Medial	Superior	Lateral	Medial		
C2	57	1	0	0	0	0	58	1.7%
C3	60	6	0	0	0	0	66	9.1%
C4	63	7	0	0	1	1	72	12.5%
C5	74	2	0	0	0	0	76	2.6%
C6	84	3	0	1	0	0	88	4.5%
C7	75	0	2	0	0	0	77	2.7%
All (C2-7)	413	22			2		437	5.5%
Perforation rate	94.5%	5.0%			0.5%			

Fig. 2

Table 2 Univariate analysis of patient demographics between the perforated screw group and non-perforated screw group

	Perforated screw group (n = 24)	Non-perforated screw group (n = 413)	P value
Age at surgery (years)	66.1 ± 14.4	61.9 ± 12.4	0.089
Sex (no. and % of female) [†]	12 (50.0%)	90 (21.8%)	0.002*
Height (cm)	158.6 ± 9.2	165.2 ± 10.3	0.003*
Weight (kg)	57.0 ± 14.1	68.2 ± 15.8	< 0.001*
Body mass index (kg/m ²)	22.5 ± 4.1	24.7 ± 4.2	0.003*
Operation time (min)	197.8 ± 53.4	202.0 ± 53.8	0.677
Estimated blood loss (mL)	81.0 ± 67.9	87.2 ± 57.6	0.317
Number of instrumented segments (no.)	4.1 ± 1.3	3.7 ± 1.4	0.451
Number of decompressed segments (no.)	3.0 ± 2.1	3.4 ± 1.7	0.148
Cervical pedicle screw diameter (mm)	3.7 ± 0.2	3.9 ± 0.2	0.441
Cervical pedicle screw length (mm)	23.7 ± 1.5	24.1 ± 1.8	0.473
Diagnosis (no. and %) [†]			0.121
Surgeon (no. and % of Fellow Surgeon) [†]	8 (33.3%)	41 (9.9%)	< 0.001*

* Statistically significant ($p < 0.05$)All data expressed as means ± standard deviation. A Mann-Whitney U test. [†]Chi-square test