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Assessment of Spinal Column Stability for Image-Guidance After Lateral Corpectomy

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Introduction

Lateral corpectomies are well-established procedures that have been used successfully in the treatment of numerous conditions, including infection, deformity, tumor, trauma, and degenerative disease [1]. To re-establish vertebral body stability post resection, cage placement is typically performed, with proper alignment of the cage between the superior and inferior bodies to ensure vertebral column alignment and fusion. Image-guidance provides enhanced visualization in spinal surgical procedures, particularly for accuracy of implant placement. However, image guidance with dynamic referencing depends on stability of the anatomy relative to the patient reference frame for accuracy of visuals provided by the system. A cadaveric study was conducted to evaluate stability of the spine following partial and full corpectomy procedures to assess the ability to accurately navigate cage placement post-corpectomy.

Methods

Two cadavers were prepped in the right decubitus position per typical clinical setup. Thoracic and lumbar access was performed for one cadaver, with lumbar access only for the second. Two fiducials each were placed in the superior and inferior bodies above and below the planned corpectomy levels (Centerpiece Screws; Medtronic PLC, Dublin, Ireland) followed by 3D imaging to establish the pre-procedure state of the anatomy (O-arm, Medtronic PLC). For the procedures, a partial corpectomy was performed using osteotomes and roungeurs, with screw hole prep to simulate lateral plating, followed by final extension of the resection to a full corepectomy. Additional 3D imaging was conducted after each procedure (partial and full) to establish the post-procedure state of the anatomy. Image data was post-processed with Mimics (Materialise, Leuven, Belgium) to segment the fiducials. 3D models of the fiducials were exported to Geomagic (3D Systems, North Carolina, USA) to assess displacement of the vertebral bodies and relative shift of fiducials with respect to the pre-procedure state (Figure 1).

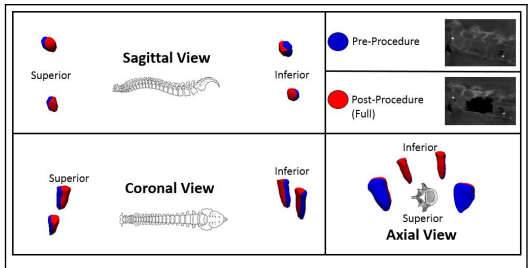

Figure 1: Reconstructed fiducials at pre and post procedure states (cadaver 2, lumbar).

Results

Table 1 shows the change in distance between fiducials pre and post procedure. Fiducials 1 and 2 represent the superior body and fiducials 3 and 4 represent the inferior body. Distance changes between fiducials on the same body show a maximum value of 0.31, representing the error of the fiducial reconstruction. Distance change between fiducials 1-4 and 2-3 represent the impact of the corpectomy procedure on spinal column stability, with a maximum value of 1.58 mm between the pre and full lumbar corpectomy states (cadaver 2). Table 2 shows the relative shift of the fiducials after registration of the scans, with a maximum positional shift of 1.42 mm between the pre and full lumbar corpectomy states (cadaver 1). Directionality of the positional shift was generally contraction of the bodies including lateral shift from midline.

Table 1: Distance between fiducials at pre and post procedure states.

Cadaver 1 Lumbar					
	Pre	Partial	Full	Delta Pre/Partial	Delta Pre/Full
Distance 1-2 (mm)	18.33	18.35	18.24	0.02	0.09
Distance 3-4 (mm)	18.16	17.97	17.85	0.20	0.31
Distance 1-4 (mm)	69.82	70.58	70.48	0.76	0.66
Distance 2-3 (mm)	68.86	68.88	68.78	0.01	0.08
Cadaver 1 Thoracic					
	Pre	Partial	Full	Delta Pre/Partial	Delta Pre/Full
Distance 1-2 (mm)	15.68	15.81	15.80	0.13	0.12
Distance 3-4 (mm)	15.18	15.38	15.40	0.20	0.23
Distance 1-4 (mm)	43.91	42.87	42.86	1.04	1.05
Distance 2-3 (mm)	43.11	42.24	42.16	0.87	0.95
Cadaver 2 Lumbar					
	Pre	Partial	Full	Delta Pre/Partial	Delta Pre/Full
Distance 1-2 (mm)	18.40	18.40	18.53	0.00	0.13
Distance 3-4 (mm)	13.15	13.28	13.18	0.13	0.02
Distance 1-4 (mm)	75.90	74.73	74.71	1.16	1.19
Distance 2-3 (mm)	73.98	72.43	72.40	1.55	1.58

Table 2: Relative shift of fiducials between pre and post procedures states.

Cadaver 1 Lumbar		
	Pre to Partial	Pre to Full
Fiducial 1 (mm)	0.30	0.34
Fiducial 2 (mm)	0.17	0.33
Fiducial 3 (mm)	0.36	0.13
Fiducial 4 (mm)	0.65	1.42
Cadaver 1 Thoracic		
	Pre to Partial	Pre to Full
Fiducial 1 (mm)	0.41	0.82
Fiducial 2 (mm)	0.99	1.30
Fiducial 3 (mm)	0.48	0.41
Fiducial 4 (mm)	0.99	0.44
Cadaver 2 Lumbar		
	Pre to Partial	Pre to Full
Fiducial 1 (mm)	0.75	0.58
Fiducial 2 (mm)	1.00	1.01
Fiducial 3 (mm)	0.68	0.62
Fiducial 4 (mm)	0.55	0.82

Conclusions

The results show minimal change in position after both partial and full corpectomies in a cadaveric model, indicating spinal column stability despite significant bone removal. This observed stability is associated with maintenance of facet joints as well as anterior and posterior ligamentous structures, demonstrating capability for procedural accuracy with image-guidance.

References

1. Adkins DE, Sandhu FA, Voyadzis JM. Minimally invasive lateral approach to the thoracolumbar junction for corpectomy. J Clin Neurosci. Sep 2013; 20(9):1289-1294.