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Placing ball and socket cervical total disc replacement using instant center of rotation

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A B S T R A C T

Background: Authors aim to evaluate the correct placement of TDR using the instant center of rotation (ICR) as a guide.
Methods: Placement of disc would be divided into three groups using a standard of 1 mm from the ICR: Posterior to ICR, In line with ICR and Anterior to ICR.
Results: 49 patients, mean age was 39.96 ± 1.45 years. 42 intraop fluoroscopy images compared to 41 post op radiographic images demonstrated TDR in line with ICR.
Conclusion: Total discs replacements can be placed intraoperatively using proper technique with verification confirmed using the ICR postoperatively.
Keywords: Total disc replacement; instant center of rotation; ideal placement; fluoroscopy; adjacent segment disease; less exposure surgery.

1. Introduction

Spine surgery has evolved over the years of improving pain management and the introduction of motion preserving implants namely cervical disc arthroplasty.

TDR has advanced over the years with the regular use of disc implants after 1995. The main indications are patients with soft tissue herniation inducing neuralgia resistant to 6 weeks of medical therapy and patients with stenosing soft tissue herniation inducing myelopathy.[1] TDR has shown promise in improving myelopathy and radiculopathy.[2–5]

Compared to ACDF, TDR is a motion preserving technique and reproduces more closely physiologic kinematics of the cervical spine. TDR may avoid report of stresses on adjacent discs and thus potentially reduce the incidence of adjacent segment disease.[6]

After placement of TDR, it is pertinent to evaluate location intraoperatively for correct placement. This ensures that the disc is aligned with the instant center of rotation. The instant center of rotation (ICR) Fig. 1 has been proposed as an alternative to ROM for evaluating the quality of spine movement and for identifying abnormal cervical spine kinematics.[7]

We propose to evaluate the correct placement of TDR in the ambulatory setting intraoperative using the instant center of rotation[8] as a guide.

2. Methods

This was a single-center, retrospective study of prospectively collected data with a total of 49 patients who had single level total disc replacement (Prestige®, Medtronic, Minneapolis, MN, USA) in the outpatient setting. Institutional Review Board approval was obtained for the study as part of a cohort population at our institution. All operations were performed by a single surgeon, in an ASC and decision for the location was made on the outset with informed patient consent. Patients were only considered for surgery after failed conservative management for at least six weeks. Indications for TDR surgery included symptomatic, spontaneous/degenerative or traumatic herniated cervical nuclei pulposus with or without radiculopathy (Fig. 2A/B). Exclusion criteria included acute severe trauma, fracture, malignancy, infection, unstable chronic medical illnesses, prior anterior cervical fusion or total disk arthroplasty, posterior cervical procedures, and a body mass index (BMI) > 42 kg/m^2.[9] Patient-reported outcomes included preoperative and postoperative VAS and Neck Disability Index (NDI) scores.

During the operation, a representative for the implant device was in the operating room. Verification of appropriate size and location did with fluoroscopy, confirmation done with the guidance of implant rep. Follow up was at two weeks and 6 months.

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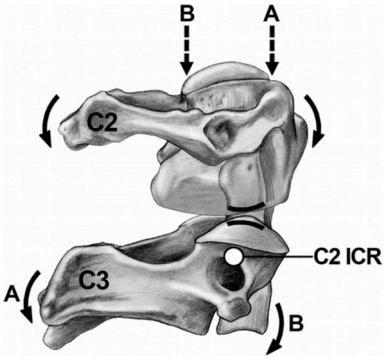

Fig. 1. Diagram depicting instant center of rotation.

2.1. Technique for distance from instant center of rotation

Images were taken intra-operatively using GE 9900 C-arm. Using RadiAnt Dicom software V1.9.4 we measured the C-spine vertebral body inferior to implant. The instant center of rotation was then extrapolated from the center of the vertebral body. TDR implant was then measured in mm and center of TDR measured from ICR.

A horizontal line was drawn connecting the inferior endplate of adjacent to disc replacement. Using the length function the center of this endplate was confirmed representing the instant center of rotation. A second horizontal line was the drawn to the inferior footprint of disc replacement and center confirmed with length function. A vertical line corresponding to ICR drawn through the center of the vertebral body. A line bisecting the long axis inferior footplate the drawn through disc replacement using Cobb angle function for angulation $< 0.1^{0}$. The distance measured using length function demonstrated the difference between the instant center of rotation and center of total disc replacement. Figs. 3 and 4 represent intra and postop imaging with measurements' respectively.

2.2. Statistical analysis

Values are expressed as mean ± standard error. Quantitative comparisons were made using the Student *t*-test. Data were analyzed using the SPSS statistical software version 22 (IBM). Tests were considered significant if $P < 0.05$.

3. Results

A total of 49 patients fulfilled our inclusion criteria. Their mean age at the time of surgery was 39.96 ± 1.45 years. There were 23 females (46%) and the mean BMI 27.62 ± 0.81.

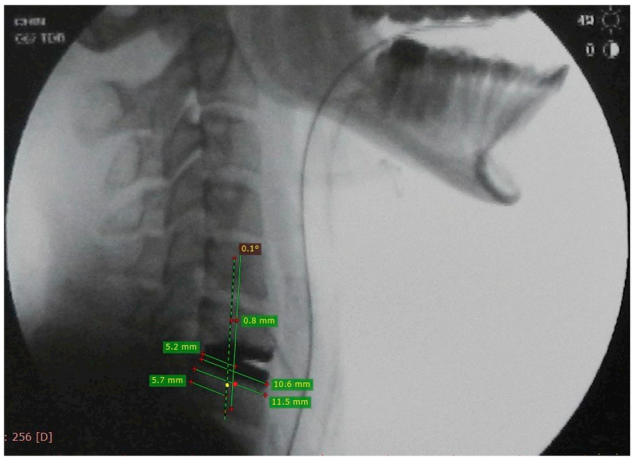

Fig. 3. Fluoroscopy showing total disc replacement and distance of center of disc from center of rotation.

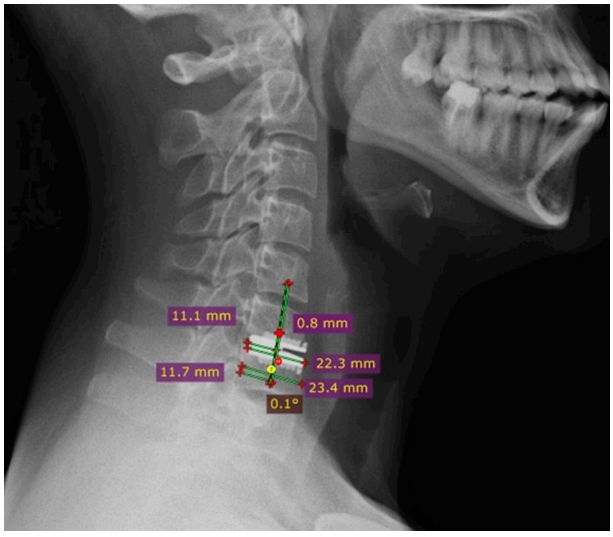

Fig. 4. Postoperative plain radiograph at 6 weeks follow up. Lateral view and distance of center of disc from center of rotation.

Demographics are summarized in Table 1, including pathological levels and chief complaint (indication for operation). Analysis of follow up at 6month period demonstrated; group 1 mean preoperative VAS neck scores improved from 7.6 ± 0.2 to 3.1 ± 0.2 at 6month follow-

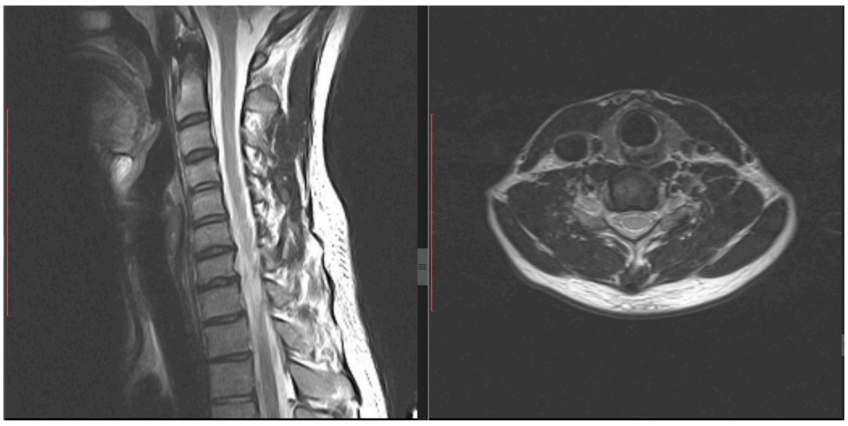

Fig. 2. A/B MRI radiograph displaying disc herniation at C6–C7 and C7-T1. A. Sagittal view B. Axial. View. C6-7 being the more affected level.

Table 1
Cohort demographics with pathological levels and chief complaint.

Variable	TDR
Age (years)	39.96 ± 1.45
BMI (kg/m^2)	27.62 ± 0.81
Male	23
Female	26
Pathological Level	
C3-4	8
C4-5	13
C5-6	21
C6-7	7
C7-T1	0
Diagnosis	
Herniated disc	32
Degenerative disc disease	7
Spondylosis (chronic pain)	0
Myelopathy	0
Radiculopathy	10

up, $p < 0.001$. Preoperative VAS arm score improved from 5.8 ± 0.2 to 1.6 ± 0.1, $p < 0.001$. Preoperative mean NDI score decreased from 67.3 ± 2.0 to 30.8 ± 1.1 at 6 months follow up, $p < 0.001$. The mean distance between ICR and center of disc intraop was 0.83 ± 0.03 compared to postop mean of 0.91 ± 0.3, $p = 0.093$.

4. Discussion

The aim of our study was to verify the technique of placement of TDR and to demonstrate that implants were in the ideal place using the instant center of rotation as our guide.

The move toward motion preservation has been prompted by adjacent segment degeneration associated with ACDF. Radiographic analysis of adjacent segment degeneration has been documented in long-term studies. Baba et al. studied 106 patients who underwent ACDF for cervical myelopathy with an average of 8.5 years of follow-up.[10] He found that 25% of patients developed spinal canal stenosis at the level above the previously fused segments. Gore and Sepic followed 121 patients who had undergone an ACDF for an average of 5 years.[11] They found that 25% had new-onset spondylosis, and another 25% had progression of preexisting spondylosis.

These studies highlighted the need for motion preservation to try and reduce the occurrence of ASD. There are currently several devices approved by the FDA and have undergone clinical trials[12]

Kinematics and sagittal alignment of the cervical spine post TDR has gained importance in the study as this is a means of evaluating motion preservation. There have been studies done but controversy still exists. William Anderst et al.[13] have demonstrated that there was no clinical significance in quality of motion in single arthrodesis versus asymptomatic patients. Previous results investigating adjacent segment ICR following arthroplasty or fusion have been contradictory. While two studies have indicated arthroplasty[14] and arthroplasty or fusion[15] do not affect adjacent segment center of rotation, another study found arthroplasty shifted the center of rotation in the superior motion segment in comparison to fusion.[16]

In this study, we have highlighted that implants were placed ideally in the sagittal view. We can infer that with ideal placement the axial load will go through the center of the disc which is close to the instant center of rotation as well as decrease the likelihood of migration in subsequent follow-up periods.

Conflicts of interest and sources of funding

We did not seek or receive any funding from the National Institutes of Health (NIH), Wellcome Trust, Howard Hughes Medical Institute (HHMI), or others for this work. KRC is a shareholder in and receives other benefits from SpineFrontier Inc., none of the other authors (FJRP, AB, and JAS) have any potential conflicts of interest to declare for this work.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jor.2019.04.005.

References

1. Vital JM, Boissiere L. Total disc replacement. *Orthopaedics & traumatology, surgery & research. OTSR.* 2014;100:S1–S14.
2. Heller JG, Sasso RC, Papadopoulos SM, et al. Comparison of BRYAN cervical disc arthroplasty with anterior cervical decompression and fusion: clinical and radiographic results of a randomized, controlled, clinical trial. *Spine.* 2009;34:101–107.
3. McAfee PC, Cappuccino A, Cunningham BW, et al. Lower incidence of dysphagia with cervical arthroplasty compared with ACDF in a prospective randomized clinical trial. *J Spinal Disord Tech.* 2010;23:1–8.
4. Steinmetz MP, Patel R, Traynelis V, Resnick DK, Anderson PA. Cervical disc arthroplasty compared with fusion in a workers' compensation population. *Neurosurgery.* 2008;63:741–747 discussion 747.
5. Mummaneni PV, Burkus JK, Haid RW, Traynelis VC, Zdeblick TA. Clinical and radiographic analysis of cervical disc arthroplasty compared with allograft fusion: a randomized controlled clinical trial. *J Neurosurg Spine.* 2007;6:198–209.
6. Galbusera F, Bellini CM, Brayda-Bruno M, Fornari M. Biomechanical studies on cervical total disc arthroplasty: a literature review. *Clin Biomech.* 2008;23:1095–1104.
7. Bogduk N, Mercer S. Biomechanics of the cervical spine. I: normal kinematics. *Clin Biomech.* 2000;15:633–648.
8. Erik E Swartz RTF, Cendoma Mike. Cervical spine functional anatomy and the biomechanics of injury due to compressive loading. *J Athl Train.* 2005;3:155–161, Accessed date: 1 July 2005.
9. Chin KR, Pencle FJ, Coombs AV, Packer CF, Hothem EA, Seale JA. *Eligibility of Outpatient Spine Surgery Candidates in a Single Private Practice. Clinical Spine Surgery.* 2016; 2016.
10. Baba H, Furusawa N, Imura S, Kawahara N, Tsuchiya H, Tomita K. Late radiographic findings after anterior cervical fusion for spondylotic myeloradiculopathy. *Spine.* 1993;18:2167–2173.
11. Gore DR, Sepic SB. Anterior cervical fusion for degenerated or protruded discs. A review of one hundred forty-six patients. *Spine.* 1984;9:667–671.
12. Qureshi SA, Koehler SM, Lu Y, Cho S, Hecht AC. Utilization trends of cervical artificial disc replacement during the FDA investigational device exemption clinical trials compared to anterior cervical fusion. *J Clin Neurosci : Off J Neurosurg Soc Australas.* 2013;20:1723–1726.
13. Anderst W, Baillargeon E, Donaldson W, Lee J, Kang J. Motion path of the instant center of rotation in the cervical spine during in vivo dynamic flexion-extension: implications for artificial disc design and evaluation of motion quality after arthrodesis. *Spine.* 2013;38:E594–E601.
14. Barrey C, Champain S, Campana S, Ramadan A, Perrin G, Skalli W. Sagittal alignment and kinematics at instrumented and adjacent levels after total disc replacement in the cervical spine. *Eur Spine J.* 2012;21:1648–1659 official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society.
15. Park JJ, Quirno M, Cunningham MR, et al. Analysis of segmental cervical spine vertebral motion after prodisc-C cervical disc replacement. *Spine.* 2010;35:E285–E289.
16. Powell JW, Sasso RC, Metcalf NH, Anderson PA, Hipp JA. Quality of spinal motion with cervical disk arthroplasty: computer-aided radiographic analysis. *J Spinal Disord Tech.* 2010;23:89–95.