Comparing the post-operative neck disability scores and radiographic fusion rates in Anterior Cervical Discectomy and Fusion vs. Artificial Cervical Disc Replacement

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Introduction

Cervical spinal pathology can significantly impact patient lives through clinical symptoms that include pain, sensory deficits, motor deficits, diminished reflexes, muscle spasm, or some combination of these symptoms.[1,2] This can understandably be greatly distressing to the patients who are affected. Generally, people who experience such pathology will often improve with conservative therapy.[3,4] This can include physical therapy, analgesic medication, muscle relaxants and massage.[2] However, some patients may remain symptomatic or experience worsening symptoms despite conservative management. These patients may benefit from surgical treatment.

Anterior cervical decompression and fusion (ACDF) and anterior cervical discectomy and replacement (ACDR) are two procedures that have been shown to benefit patients suffering from cervical spinal conditions.[5]

ACDF is the more commonly used procedure and has demonstrated a long history of positive outcomes since the mid-1900s.[4] This procedure involves an anterior approach for removal of all cervical disc material between the uncinate processes, replacing the disc material with a bone graft, and eventual fusion of the graft and vertebral bodies. For this procedure, autologous iliac crest bone grafting (ICBG) is considered the gold standard.[6] However, autograft use has risks associated with the donor site morbidity, such as pain, infection, hematoma, fracture, and wound healing complications.[7] Due to such donor site morbidities, there has been interest in alternate bone graft types, such as allografts. Once harvested from donors, allografts can be prepared and processed using 2 primary methods: freeze-dried or fresh-frozen.

ACDR, which is also known as cervical disc arthroplasty (CDA), is a newer technique that has been validated in several prospective, randomized clinical trials.[1] The surgery is performed with a similar approach as ACDF, but instead of bone graft material, there is an artificial disc placed into the decompressed space.[1] The theoretical advantages of ACDR over ACDF are motion preservation to protect the adjacent levels, as well as avoidance of certain disadvantages of spinal fusion, which include graft pseudoarthrosis, and autograft harvest site morbidities.[8]

Both ACDF and ACDR are indicated to treat similar cervical spinal pathology, with surgeons and patients deciding which one of these procedures to ultimately pursue. The purpose of this study is to compare the ACDF and ACDR procedures to explore any potential differences in patient outcome scores, radiograph-based measures of time to fusion (ACDF) and radiograph-based measures of time to disc incorporation (ACDR).

Statistical analysis

NDI scores were compared between the ACDF and ACDR cohorts at various time points using t-tests with significance defined as $p < 0.05$. Kaplan-Meier curves were used to compare the radiographic assessment of disc incorporation into surrounding bone (ACDR) and rate of fusion/union (ACDF). All statistical analyses and visualization for this project were conducted using SPSS, except for the Kaplan-Meier curves for the two ACDF groups (freeze-dried vs. fresh-frozen allografts). This analysis was done using SAS® software version 9.4 (SAS Institute Inc., Cary, NC).

Study Design/Methodology

This is an IRB approved, retrospective study of patients who underwent ACDF and ACDR procedures at the University of California-Davis medical center. The ACDR group included patients who underwent the ACDR procedure from 01/2014 to 01/2020. This group was compared to a cohort of patients who underwent the ACDF procedure over a similar time point from 7/2014 to 6/2020. After excluding patients who did not have pre-operative PROMs, there were 61 patients from the ACDR cohort and 37 patients from the ACDF cohort who met the inclusion criteria.

Postoperative anterior-posterior (AP) and Lateral radiographs were obtained after various follow-up time points for each patient based upon their routine care. Radiographs were analyzed and graded by medical students affiliated with the UC Davis Medical Center. For the ACDF cohort, fusion was graded based on trabecular bridging on the superior and inferior border for each fusion level. Trabecular bridging was given a percentage to correspond to the extent of fusion. For the AP/Lateral radiographs from the ACDR cohort, percentages of disc incorporation from the superior and inferior borders of the discs were recorded. (see Table 1)

Furthermore, patient Neck Disability Index (NDI) scores from 2 months, 6 months and 1 year of follow up were recorded to assess differences in postoperative discomfort and pain for patients.

ACDF		ACDR	
Fusion Grade	**Criteria**	**Disc Incorporation**	**Criteria**
Union	Complete bridging (over 50% on superior and inferior borders) at < 26 weeks	Complete	Both superior and inferior borders of disc achieve at least 50% incorporation into bone at < 26 weeks
Delayed Union	Complete bridging (over 50% on superior and inferior borders) at 26 – 52 weeks	Delayed	Both superior and inferior borders of disc achieve at least 50% incorporation into bone at 26 – 52 weeks
Fibrous Union	Lack of bridging on one or more surfaces at > 52 weeks	Not achieved	At least one (superior or inferior) border of the disc does not achieve at least 50% disc incorporation by > 52 weeks

Table 1: Radiograph interpretation guidelines

Radiographic data

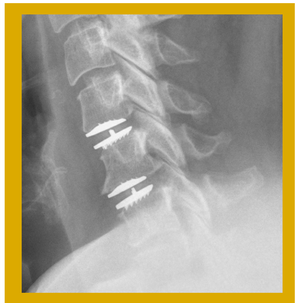

Figure 1: Patient who has had 2 cervical disc replacements featuring Mobi-C implants, C4/C5 (top) and C5/C6 (bottom). Here, we see 95% disc incorporation at the superior border and 90% at the inferior of the C4/C5 implant, as well as 90% at the superior border and 99% at the inferior border of the C5/C6 implant.

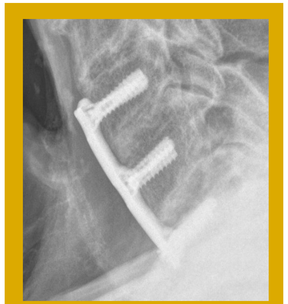

Figure 2: Cervical levels that show complete trabecular bridging on superior and inferior levels.

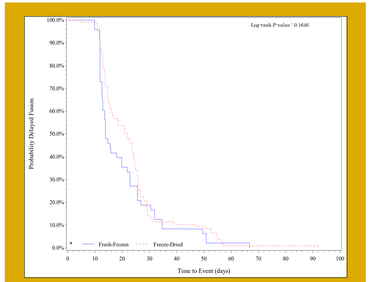

Figure 4a: Kaplan Meier curve analysis of time to fusion for ACDF
The ACDF cohort was divided based on the type of allograft that was used (freeze-dried vs fresh-frozen). For each patient, the time to fusion was analyzed to assess for differences. When comparing freeze-dried allografts (dotted red line) to fresh-frozen allografts (solid blue line), no difference was found between time to fusion. (Log rank p = 0.1646)

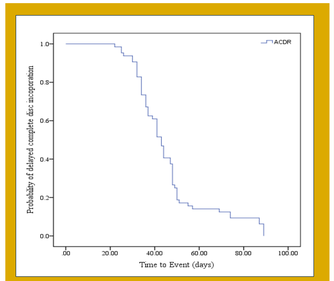

Figure 4b: Kaplan Meier curve analysis of time to complete disc incorporation for ACDR

Neck Disability Index

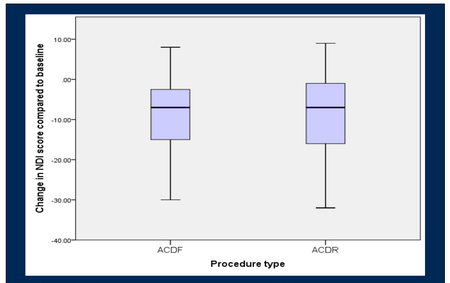

Figure 3a: Comparison of the change in NDI score between ACDF and ACDR cohorts at 6-month follow-up

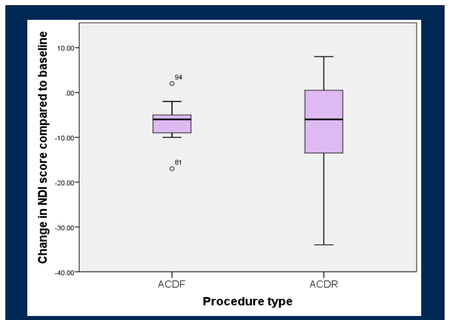

Figure 3b: Comparison of the change in NDI score between ACDF and ACDR cohorts at 1-year follow-up

Results

- Pre-op baseline NDI scores vs. 6 month follow up NDI scores: significant improvement in scores for both the ACDF group (p=0.03) and ACDR group (p=.04).
- 6 month follow up NDI scores vs. 1 year follow up NDI scores: no significant difference for the ACDF group (p=0.96) or the ACDR group (p=0.58).
- Comparing NDI scores between ACDF and ACDR groups at 6 months and 1 year: no statistically significant difference. See figure 3a/3b.
- The Kaplan Meier curves for time to fusion (ACDF) and time to complete disc incorporation (ACDR) are shown (Figure 4a/4b). Within the ACDF group, there was no significant difference in time to fusion when comparing fresh-frozen allografts to freeze-fried allografts. For ACDR, the mean time to complete disc incorporation was 46.2+/- 2.1 days. This was longer than the time to union for the overall ACDF cohort.
- For the ACDR cohort, the reoperation rate was 6.6% (4/61 patients). Reasons for reoperation included (1) recurrence of symptoms at 5 months post-op with associated implant subsidence on radiographs, (2) recurrence of symptoms at 1 year post-op without associated radiographic changes, (3) adjacent segment disease and symptoms at 5 months post-op, and (4) auto fusion and recurrence of symptoms at 2 years post-op.

Discussion

Both ACDF and ACDR seem to have similar improvements in early NDI, and those improvements peak and remain stable at 6 months without much more improvement by 1 year.

The lack of statistically significant differences in the change in NDI scores between ACDF and ACDR groups at 6 months and 1 year likely reflect that both procedures result in similar levels of improvement in neck disability at both time points.

When assessing time to union (ACDF) and time to complete disc incorporation (ACDR), the ACDF group had a shorter time to union. Despite this, the NDI scores are not significantly different between the groups at the 6 month and 1 year follow-up times. This may indicate that both procedures have positive short-term outcomes with regards to improvement of neck disability despite different rates of bony union and disc incorporation, respectively.

Within this small (n=61) cohort of ACDR patients, there were 4 re-operations within the first 2 years after disc replacement surgery. Two of these complications were implant-related, with reasons including implant subsidence and auto fusion.

Conclusions/Further Study

In this retrospective, nonrandomized trial, ACDF performed similarly to ACDR for the treatment of cervical pathology with similar improvement in disability. There is a faster time to union for the ACDF vs ACDR group. The limitations of the present study include a relatively small cohort size with short follow-up. It also only focuses on neck disability as approximated by NDI scores but does not consider neurological outcome scores which are also an important aspect of patient recovery.

Future research should focus on the bony union and incorporation of the artificial cervical disc device and its impact on outcomes, as well as potential for need for additional surgery. A larger, prospective cohort study may be appropriate.

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