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Alternative grafts in anterior cervical fusion

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ABSTRACT

Objective: The present retrospective study was conducted to compare the clinical and radiographic outcomes in patients undergoing anterior cervical discectomy with fusion (ACDF) using carbon fiber reinforced polymer (CFRP) cages, or allograft.
Methods: We retrospectively reviewed cases of ACDF using allograft in 20 patients, and CFRP in 19 who had sequential radiographs before and after surgery, and at 1 year.
Results: There were no apparent significant differences between the 2 groups in age ($p = 0.057$), gender ($p = 0.635$), or complications ($p = 0.648$). At 12 months, there were no cases of construct failure, and fusion appeared to have been achieved in patients of both groups. Lordosis was increased significantly in both groups after surgery ($p < 0.001$ in allograft and $p = 0.025$ in CFRP), and was maintained up until 1 year ($p < 0.018$ in allograft and $p = 0.05$ in CFRP) without a difference between groups ($p = 0.721$). Anterior interbody height was significantly increased ($p < 0.001$ in both groups at each time points) after surgery, without a significant difference between groups ($p > 0.21$). This increase in height was greatest in magnitude immediately after surgery, and declined with the passage of time. There was no detectable health-related quality of life difference between allograft and CFRP group after surgery ($p > 0.05$).
Conclusion: The present study demonstrates that CFRP cages appear to have comparable fusion rates, restoration of lordosis and disc space height, and complication rates to patients who undergo ACDF with allograft.

1. Introduction

Anterior cervical discectomy with fusion (ACDF) is regarded as a standard surgical solution for cervical spondylosis with myelopathy, radiculopathy, disc herniation or other ventrally derived cervical diseases refractory to conservative management. To promote fusion and maintain foraminal height, interbody grafts are implanted. Graft material used for interbody fusion includes autologous iliac crest, cadaveric allograft, and bone substitutes [1–6]. Although autografts are the ideal choice for the promotion of fusion, to which alternatives are compared, morbidity from the donor site prompts the search for alternative interbody grafts [7–9]. Allografts from cadaveric bone have an acceptable fusion rate [2,10,11], however require stringent selection of donors and processing to reduce the possibility of transmissible diseases such as hepatitis and human immunodeficiency (HIV) viruses, tuberculosis and others [12–14]. To avoid this potential hazard, cages from alternative synthetic materials have been advocated. Such alternatives include cages from titanium, ceramic, PEEK, and carbon fiber reinforced polymer (CFRP, Bengal cages, 30% carbon fiber, 70% polyetheretherketone (PEEK), DePuy Spine, Raynham, MA). The latter has the advantage over titanium for its radiolucency, and over PEEK alone because of its greater strength in both compression and tension [15].

A retrospective cohort study was conducted to compare the clinical and radiographic outcomes in patients undergoing ACDF with CFRP cages packed with autologous bone marrow-saturated hydroxyapatite wafers (Healos, DePuy Spine, Raynham, MA), or allograft. Potentially, synthetic grafts such as CFRP, would not be subject to the resorption that can occur with auto- or allograft. The hypothesis was that compared to allograft, CFRP would be more likely to correct and maintain lordosis over time.

2. Materials and methods

2.1. Patient selection

All cases of anterior cervical discectomy and interbody fusion using either allograft or CFRP cages at the University of Iowa

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Table 1
Demographics of patients in both groups.

	Allograft	CFRP	*p*
No. of patient	20	19	
Age (mean ± SD)	49.7 ± 10.9	57.3 ± 13.3	0.057
M/F	8/12	9/10	0.635
Length of hospitalization	2.6 ± 1.8	3.3 ± 2.7	0.340
C2-3	1	0	–
C3-4	2/38	7/44	0.166
C4-5	11/38	8/44	0.299
C5-6	12/38	17/44	0.644
C6-7	12/38	12/44	0.808
Number of levels fused	1.9 ± 0.85	2.32 ± 0.58	0.085
Dysphagia	2	2	
CSF leaks	2	1	

Hospitals and Clinics from July 2005 to March 2010 were followed for a minimum of 1 year, and retrospectively reviewed. Procedures due to revision, trauma, tumors, and infections were excluded. All CFRP procedures were performed by the senior author (PWH). Allograft procedures were performed by other faculty. There were 20 allograft patients treated between February 2008 and January 2010, and 19 CFRP patients treated between May 2006 and September 2009 who had sequential radiographs before surgery, after surgery and at 1 year and constitute the population of this study (Table 1).

2.2. Operation and postoperative follow-up

In the CFRP cage group, at the beginning of the case, 2.5 ml of bone marrow, per level, was harvested from the iliac crest using a 14 gauge needle with side opening. The bone marrow aspirate (BMA) was applied on a 2.5 ml Healos wafer (70% collagen, 30% hydroxyapatite coating, DePuy Spine, Raynham, MA) [16,17] to pack into the CFRP cage at the time of graft insertion. As for the allograft group, freeze-dried, vacuum sealed cadaveric allograft (Cornerstone, Medtronic Sofamor Danek, Memphis, TN) was immersed in an antibiotic solution at least 30 min prior to use.

Following discectomy and preparation of the endplates, sizing was carried out using templates to achieve restoration of disc space height, comparable to levels above and below, and provide for a snug fit. In cases of CFRP implants, the cage, with a 7° lordotic angle, was filled with bone marrow-soaked Healos was impacted into the prepared disc space under fluoroscopic guidance (Fig. 1). For cases using allograft, with standard 6° of lordosis, the disc space was also sized, and an appropriate graft snuggly impacted into the prepared disc space (Fig. 2). In some cases the decompression and fusion involved multiple levels. At the completion of discectomy and implantation of the grafts, an appropriately sized plate was selected and secured with semi-constrained screws (Slim-lock, DePuy Spine for the CFRP cages, and Venture, Medtronic for the allograft fusions) to the vertebral bodies.

In all patients, antero-posterior and lateral cervical radiographs were obtained within 24–48 h following surgery. The follow-up X-ray was repeated at 3, 6 and 12 months after surgery. In accordance with the literature [1,18], lateral radiographs were used to observe changes in angulation and height (Fig. 3). Measurements were made by the authors (F.C., K.M., and P.W.H.) with consensus. Height was measured between the anterior endplates and posterior endplates on the lateral radiograph. To correct magnification variation in the radiographs, the height of the disc space of interest was converted to a ratio of the height over the mid anteroposterior diameter of the superior vertebral body: anterior disc height ratio (ADHR) and posterior disc height ratio (PDHR) (Tables 2 and 3). The

Table 2
Comparison of radiographic parameters between groups across time.

Parameter	Time points	Group	Mean	S.D.	*p*
Angulation	Pre-op	Allograft	−1.08	3.75	0.456
		CFRP	−1.89	5.66	
	Post-op	Allograft	−5.42	3.94	0.254
		CFRP	−4.43	3.84	
	Post-op 12 m	Allograft	−3.76	5.39	0.721
		CFRP	−4.16	4.63	
ADHR	Pre-op	Allograft	0.22	0.09	0.219
		CFRP	0.24	0.06	
	Post-op	Allograft	0.48	0.12	0.21
		CFRP	0.42	0.08	
	Post-op 12 m	Allograft	0.41	0.12	0.221
		CFRP	0.38	0.11	
PDHR	Pre-op	Allograft	0.18	0.08	0.455
		CFRP	0.20	0.07	
	Post-op	Allograft	0.34	0.12	0.152
		CFRP	0.31	0.07	
	Post-op 12 m	Allograft	0.28	0.12	0.043
		CFRP	0.23	0.08	

Cobb's angle of the fused disc space was measured between the two vertebral endplates on the lateral radiograph as indicated in Fig. 3. Fusion was based on the presence of bone growth through the graft on plain radiographs at 1 year, in addition to flexion and extension films, as described in recent literature [19–23] Where fusion could not be confirmed on plain lateral X-rays, and if clinically indicated CT scan were obtained.

To compare the cost of implants, hospital charges of all 20 allograft and 19 CFRP patients were retrieved. As patients had a multitude of insurance carriers with different policies, we elected to compare charges rather than actual fees collected. Total charges include surgeons' and anesthesiologists' fees, operative and postoperative charges incurred by the patient, plus the cost of implants, grafts, and plates.

For a comparison of outcomes between the CFRP and allograft groups, patients were assessed at their last follow-up using the Odom criteria [1,24–26]. Using these criteria patients were scored excellent with no complaints referable to cervical disease and no impairment, good with intermittent discomfort related to cervical disease but without interference with work, satisfactory with subjective improvement but whose physical activities were limited, and poor in the absence of improvement or worse compared to their preoperative status. In addition, the health status profile forms (SF-36) were forwarded and completed by patients following surgery at 1.6 ± 0.6 years for the allograft group, and 2.2 ± 1.2 years for the CFRP group. The SF 36 is a questionnaire consisting of 36 items that measure eight physical health and mental health domains, including limitations in physical activities because of physical health problems (pain, physical function, health limitations and general health) and limitations in social activities because of mental health problems (social functions, emotional limitations, energy and emotional role).

3. Statistical analysis

Disc height and angulation were reported as mean ± standard deviation ($M \pm SD$). Differences in disc height and angulation between different graft groups (allograft versus CFRP cage) were compared immediately after surgery, and at 12 months after surgery. SPSS 17.0 for windows was used to conduct statistical analysis. Generalized linear model (GLM) repeated measures procedure was used for analysis. A p value ≤ 0.05 was regarded as statistically significant at confidence intervals of 95%. Categorical data are