Clinical Neurology and Neurosurgery 162 (2017) 95–100

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Posterior atlantoaxial fusion with a screw-rod system: Allograft versus iliac crest autograft

Da-Geng Huang[a], Xin-Liang Zhang[a], Ding-Jun Hao[a,*], Cheng-Cheng Yu[a], Bai-Bing Mi[b], Qi-Ling Yuan[c], Bao-Rong He[a], Tuan-Jiang Liu[a], Hua Guo[a], Xiao-Dong Wang[a]

[a] Department of Spine Surgery, Honghui Hospital, Xi'an Jiaotong University, No. 555 Youyi East Road, Xi'an, Shaanxi, 710054, China
[b] Department of Epidemiology and Biostatistics, School of Public Health, Xi'an Jiaotong University, No. 76 Yanta West Road, Xi'an, Shaanxi, 710061, China
[c] Department of Orthopaedics, First Affiliated Hospital, Xi'an Jiaotong University, No. 261 Yanta West Road, Xi'an, Shaanxi, 710061, China

ARTICLE INFO

Keywords:
Atlantoaxial fusion
autograft
allograft
screw-rod fixation

ABSTRACT

Objective: To compare the effectiveness of allograft and iliac crest autograft in atlantoaxial fusion.
Patients and Methods: Between January 2012 and December 2012, 41 consecutive patients underwent posterior atlantoaxial fusion with a screw-rod fixation system in our spine center. The choice to use allograft or iliac crest autograft was made by the patient himself or herself after being informed about the advantages and disadvantages of both methods. In the allograft group, we used mixed material of morcellized demineralized freeze-dried bone allograft and local autograft for posterior atlantoaxial fusion. In the autograft group, we used the morcellized iliac crest autograft for fusion. Patients underwent regular follow up including CT scans and dynamic radiographs 6 months postoperatively and every 6 months thereafter until study completion or confirmation of fusion.
Results: Twenty-four patients underwent posterior atlantoaxial fusion with allograft, and 17 underwent fusion with autograft. All patients were followed up for at least 24 months. At the final follow-up visit, only two (8.3%) patients in the allograft group had confirmed posterior bony fusion on CT imaging while 15 (88.2%) patients in the autograft group had confirmed posterior bony fusion. None of the 41 patients had movement on the dynamic radiographs.
Conclusions: Allograft is not reliable for posterior atlantoaxial fusion even with the rigid internal fixation of modern constructs. Autograft remains the first choice for atlantoaxial fusion despite the donor-site morbidity. The assessment of fusion based on a lack of movement on dynamic radiographs is not reliable. The confirmation of fusion should be based on the presence of bridging bone on CT imaging.

1. Introduction

Autograft bone is used very often in posterior atlantoaxial fusion and has been reported to obtain excellent fusion rates with modern atlantoaxial fixation constructs [1]. However, donor-site morbidity remains a significant challenge [2]. Some authors have reported using allograft rather than autograft bone to avoid donor-site complications in posterior atlantoaxial fusion with satisfactory results [3–7]. However, the assessment of fusion is different in different studies. Most authors define fusion as the absence of movement on dynamic radiographs, which is not reliable [3–5,7]. The evaluation of fusion should be based on the presence of bridging bone on computed tomography (CT) imaging [8]. To the best of our knowledge, there is no comparative study to directly compare the effectiveness of allograft and autograft in atlantoaxial fusion with screw-rod fixation routinely using CT imaging as of yet. Here, we performed a prospective comparative study that compared the effectiveness of allograft and autograft in atlantoaxial fusion by both CT imaging and dynamic radiographs.

2. Patients and Methods

2.1. Patients

Between January 2012 and December 2012, 41 consecutive patients with Os odontoideum or odontoid fracture and that required atlantoaxial fusion were enrolled. Patients were assigned to two groups based on the grafting material used: the allograft group, using mixed material of morcellized demineralized freeze-dried bone allograft and local autograft for fusion; and the autograft group, using morcellized iliac crest autograft for fusion. The patient decided whether to use

* Corresponding author.
E-mail address: 345070558@qq.com (D.-J. Hao).

http://dx.doi.org/10.1016/j.clineuro.2017.10.002
Received 11 August 2017; Received in revised form 26 September 2017; Accepted 1 October 2017
Available online 03 October 2017
0303-8467/

allograft or iliac crest autograft after being informed about the advantages and disadvantages of both methods. The information was presented to the patients by a trained doctor who did not take part in the surgery and was blinded to the study.

2.2. Surgical procedures

After general endotracheal anesthesia, all patients were placed in the prone position, and the posterior elements of C1–C3 were exposed by a standard posterior approach. The medial and lateral margins of the lateral mass of the axis and posterior surface of the posterior lamina of the atlas were dissected. Screws were placed in accordance with Tan's technique [9], which has been shown to achieve the highest screw placement success rate compared with a variety of published techniques for atlas pedicle screw placement [10]. If the C1 pedicle was too narrow to accommodate a screw, we used the C1 lateral mass screw technique described by Harms and Melcher [11] instead. C2 pedicle screws were inserted regularly [11]. The ipsilateral C1 and C2 screws were connected by a rod. After atlantoaxial fixation by the screw-rod system, the bone graft bed was prepared by a high-speed burr. C1–2 joint decortication was not performed. For the allograft group, the mixed material of morcellized demineralized freeze-dried bone allograft (usually the amount of allograft we used was about 3–4 g) and local autograft (usually the local autograft was very limited) was used for posterior atlantoaxial fusion. For the autograft group, morcellized iliac crest autograft harvested from the posterior iliac crest was used for posterior atlantoaxial fusion. Neither bone morphogenetic proteins nor demineralized bone matrix was used in any of the patients in the study.

2.3. Clinical and radiographic evaluation

The operation time, blood loss, and perioperative complications (vertebral artery injury, spinal cord injury, incision infection, and wound dehiscence) were recorded. All patients were followed up regularly with dynamic radiographs and CT scans 6 months postoperatively and every 6 months thereafter until fusion was confirmed or until study completion. Neurological deficits were measured with the Japanese Orthopedic Association (JOA) scoring system. Neck pain was assessed using the Visual Analogue Scale (VAS) score. Fusion was determined based on the presence of bridging bone between C1 and C2 laminas on CT imaging. Stability was determined based on the lack of movement on dynamic radiographs. The judgment of fusion and stability was made by a trained radiologist who was blinded to the study.

2.4. Statistical analysis

The demographic characteristics of the two groups were compared using the independent *t* test to compare mean values; the χ^2 test was used to compare proportional data. There was no statistically difference between groups with regards to demographic characteristics (Table 1). Fusion rates, stability rates, perioperative complication rates, blood loss, operative times, JOA score before surgery, JOA score at the final follow-up, VAS score before surgery, and VAS score at the final follow-up were compared between groups. The preoperative JOA score and that at the final follow-up as well as the preoperative VAS score and that at the final follow-up were also compared in each group. The demographic characteristics of those who were stable on dynamic radiographs with successful bony fusion on CT scans and those who were stable on dynamic radiographs without successful bony fusion on CT scans were also compared. There was no statistically difference between groups with regards to demographic characteristics (Table 2). And then further comparison of clinical outcomes (JOA scores and VAS scores) of those patients was made. The SPSS version 18.0 statistical software (SPSS Inc., Chicago, IL) was used for data entry and analysis. A p-value of less than 0.05 was considered statistically significant.

Table 1
Demographic and baseline characteristics of the 41 patients.

	Allograft group	Autograft group	*P*
Number of cases	24	17	–
Mean age (years)	43.6 ± 12.0	41.1 ± 14.1	$P = 0.535$
Sex (male/female)	14/10	10/7	$P = 0.975$
Main diagnosis (Os odontoideum/odontoid fracture)	11/13	7/10	$P = 0.767$

$P < 0.05$ was considered statistically significant.

Table 2
Demographic characteristics of patients who were stable on dynamic radiographs with successful bony fusion on CT scans and those without successful bony fusion.

	With successful bony fusion	Without successful bony fuion	*P*
Number of cases	17	24	–
Mean age (years)	37.4 ± 13.6	46.3 ± 11.2	$P = 0.356$
Sex (male/female)	10/7	14/10	$P = 0.975$
Main diagnosis (Os odontoideum/ odontoid fracture)	7/10	11/13	$P = 0.767$

$P < 0.05$ was considered statistically significant.

3. Results

All 41 patients were followed up for at least 24 months with a mean follow-up period of 25.6 (range 24–36) months. There were 24 patients (14 males and ten females; mean age 43.6, range 22–65 years) in the allograft group. There were 17 patients (ten males and seven females; mean age 41.1, range 18–64 years) in the autograft group. The allograft group included 13 cases of odontoid fractures and 11 cases of Os odontoideum. The autograft group included 10 cases of odontoid fractures and 7 cases of Os odontoideum (Table 1).

Surgery was successful in all patients. The results of the evaluation indices are shown in Table 3. The mean blood loss was 170.8 ± 60.6 (range 100–300) ml in the allograft group versus 235.3 ± 46.0 ml (range 150–300) ml in the autograft group ($P < 0.001$). The mean operative time was 123.3 ± 18.3 (range 90–160) min in the allograft group versus 142.4 ± 23.6 (range 110–180) min in the autograft group ($P = 0.006$). One patient in the allograft group suffered wound dehiscence caused by incisional fat liquefaction. One patient in the autograft group suffered severe immediate postoperative donor site pain and another suffered donor site incision superficial infection. The donor-site morbidity was 11.8% in the autograft group. The overall

Table 3
Results of evaluation indices for the 41 patients.

	Allograft group	Autograft group	*P*
Fusion rate[a]	8.3%	88.2%	$P < 0.001$
Stability rate[b]	100%	100%	–
Perioperative complication rate	4.2%	11.8%	$P = 0.755$
Blood loss (ml)	170.8 ± 60.6	235.3 ± 46.0	$P < 0.001$
Operative time (min)	123.3 ± 18.3	142.4 ± 23.6	$P = 0.006$
JOA[c] score before surgery	13.3 ± 2.3	13.2 ± 2.5	$P = 0.882$
JOA score at final follow-up	16.0 ± 1.0	16.0 ± 0.9	$P = 0.893$
VAS[d] score before surgery	5.6 ± 1.8	5.9 ± 1.6	$P = 0.571$
VAS score at final follow-up	1.1 ± 0.5	1.3 ± 0.6	$P = 0.345$

$P < 0.05$ was considered statistically significant.
[a] Evaluated by CT imaging.
[b] Evaluated by dynamic radiographs.
[c] JOA, Japanese Orthopedic Association.
[d] VAS, Visual Analogue Scale.