Anterior Debridement, Bone Grafting And Fixation For Cervical Spine Tuberculosis :Iliac Bone Graft Versus Structural Manubrium Graft

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Abstract

Background The purpose of this retrospective study was to compare the clinical outcomes of anterior surgical management for cervical spinal tuberculosis by iliac bone grafts versus structural manubrium graft.

Methods From January 2009 to September 2018, 23 patients with cervical spinal tuberculosis were treated with anterior debridement, autogenous structural bone graft and fixation at our spinal department. The patients were divided into 2 groups according to the different graft material, including iliac crest bone grafts in group A, structural manubrium grafts in group B. The clinical and radiographic results for the 2 groups were analyzed and compared.

Results The mean duration of follow-up was 24 months. Bony fusion was achieved in all cases without failure of internal fixation. There were no significant differences between groups regarding the operation time, blood loss, fusion time, neurological outcomes, and postoperative local Cobb angle ($P > .05$). However, the donor site complication rate of Group A was more than that of Group B. Postoperative ambulation time in group A was later than that of group B. The mean visual analog scale (VAS) for donor-site pain in group A was higher than group B at a week after surgery ($P < 0.05$). However, there was no significant difference between the 2 groups at last visit ($P > .05$).

Conclusion Both iliac bone grafts and sternal manubrium grafts can effectively reconstruct anterior column defects in anterior surgery. However, structural sternal manubrium autografts has less complications associated with donor site morbidities than that of iliac bone.

Introduction

Although anti-TB chemotherapy and improved nutrition have resulted in excellent functional outcomes in some patients, patients with severe kyphosis, developing neurological deficit, or therapeutically refractory disease need to surgical intervention[1-2]. It is generally accepted that the aim of surgical treating spinal tuberculosis (TB) is to debride the lesion, remove the spinal cord compression, correct spinal deformity. Anterior surgery is a commonly performed procedure for the treatment of lower cervical spine tuberculosis[3]. However, the reconstruction of bony defects after debridement remains a major challenge.

Autologous iliac bone graft is still regarded as the “gold standard” for its superior osteoinductive and osteoconductive properties. However, the high incidence of associated donor site morbidities remains a major concern[4]. To prevent these complications, multiple alternative bone grafting, such as vascularized fibular graft, allograft, titanium mesh and synthetic interbody cages, have been developed as a substitute for autologous iliac bone. The advantages and disadvantages of these surgical options have been described extensively in the literature[5-8].

In recent years, the manubrium is considered as a novel source of cancellous autograft for cervical fusion. To obtain cancellous bone from manubrium has been reported in several studies, with satisfactory fusion

and less donor-site complication[9-10]. There was no relative report about harvest a manubrial autograft to serve as a structural graft. In this study we describe a method using structural bone obtained from manubrium for the treatment of cervical spine tuberculosis. Here, with iliac bone grafting as the control group, we compare the clinical and radiography outcomes of two groups for the treatment of lower cervical spine tuberculosis.

Materials And Methods

Population data

From January 2009 to September 2018, patients with cervical tuberculosis underwent surgery in our hospital were initially reviewed retrospectively. The diagnosis of tuberculosis was first made on the basis of medical history, clinical examination, laboratory results (erythrocyte sedimentation rate, ESR, C-reactive protein, CRP), radiologic imaging (X-ray, CT, and MRI), and drug response. A definitive diagnosis was made by histological examination and/or by polymerase chain reaction (PCR) of tissue removed at surgery. The indications for surgery were severe kyphosis of the cervical spine, spinal instability, and neurologic deterioration. The inclusion criteria: (1) the lesion involved lower cervical vertebra (C3-C7), (2) underwent debridement, autogenous bone graft and instrumentation by anterior-only approach, (3) definitive diagnosis of TB by pathological examination or PCR, (4) with a minimum 2-year follow-up. Exclusion criteria: (1) Multiple cervical vertebrae damage; (2) Patients with posterior column of tuberculosis lesions, (3) loss of follow-up data for any reason. According to different bone grafting methods, they were divided into two groups: iliac bone graft in group A; structural manubrium graft in group B.

Preoperative Examination and Preparation

All patients underwent anti-TB treatment by daily oral administration of isoniazid 300 mg, rifampin 450 mg, ethambutol 750 mg, and pyrazinamide 750 mg for at least 2-4 weeks preoperatively according to previous study[11]. Patients with malnutrition were given parenteral nutrition to improve their preoperative condition.

Before surgery, patients were informed that various options for anterior cervical reconstruction using either an (1) iliac bone graft, (2) structural manubrium graft or (3) titanium mesh cages with allograft. The advantages and disadvantages of each of these options were discussed extensively with the patients by the surgeon and signed consent form. 3D-CT (3-dimensional computed tomography) was performed to investigate the anatomy of manubrium for every patients who selected sternal graft. In the workstation, the breadths, height and thickness of manubrium were measured as peng described[12] [Fig.1a,b]. If the presence of extremely small or malformed manubrium, substitutable procedure should be considered so as to avoid pitfalls.

Surgical Technique

All operations were performed by one of three senior surgeons in our institute. The surgery was divided into 3 steps. The first step was radical debridement of cervical tuberculosis through the Smith-Robinson anterolateral approach. The height of anterior gap was measured after washing the wound repeatedly. The step 2 of the surgery was harvest of bone graft. The iliac bone harvesting technique was performed in group A according to the method of previous literature.[4] Structural bone was harvested from manubrium in group B as follows. A longitudinal or transverse 3-cm incision is made directly over the manubrium. Dissection is carried down through the subcutaneous tissue to the periosteum. The anterior aspect of the manubrium was exposed to the medial limits of the sternoclavicular joints. Sternal block was harvested using piezosurgery, which was limited by the sternoclavicular joints laterally, and 0.5 cm above the sternal angle cephalic and below suprasternal notch, respectively [Fig.3h]. Then, hemostasis was performed carefully by bipolar electrocoagulation. The defect of manubrium was reconstructed with gelatin sponge and remaining morselized bone. Finally, a drainage tube was placed and the incision was closed in layers.

The last step was graft and fixation. The anterior defect created by surgery was reconstructed by iliac bone autograft in group A [Fig.2], while the gap was reconstructed by structural manubrium autograft in group B [Fig.3]. Then, anterior cervical fixation was performed with a locking plate-screw system of appropriate length. After hemostasis and washing was performed, deep drainage tube was placed and the incision was closed in layers.

Postoperative care

After surgery, the drainage tube was removed when the volume of drainage was less than 50 ml/24 h. Patients were encouraged to walk with the support of a neck brace after 3 days of the surgery. Anti-tuberculosis chemotherapy was continued for 3 months postoperatively (isoniazid 300 mg, rifampin 450 mg, ethambutol 750 mg, and pyrazinamide 750 mg), followed by a regimen of isoniazid, rifampicin, and ethambutol for another 12-15 months[3].

Clinical evaluation and follow-up

Patient follow-up occurred at 3 months, 6 months, 1 year post-operatively and all findings were recorded by the surgeon. The primary outcomes measured were ESR, Cobb, VAS score, complications, fusion rate. At each follow-up, lateral X-ray films or CT were obtained. Fusion was assessed by the presence of bridging trabecular bone and absence of radiolucency at the junction between the graft/cage and opposing vertebra[13].

Results

According to the inclusion criteria, a total of 23 patients were enrolled in this study. There were 15 patients (10 males and 5 females) with a mean age of 38.5 years in group A, and all patients underwent anterior debridement, iliac bone graft and fixation. In group B, there were 8 patients (4 males and 4 females) with a mean age of 49.5 years and all of them were managed with anterior

debridement, structural sternal block graft and instrumentation. All patients were followed up for an average of 24 months. The basic information of patients in two groups are shown in **Table 1**.

Table 1. The basic information of patients in two groups

Characteristic	Group A(15 patients)	Group B(8 patients)	p
Age	47.6.5±8.4	50.7±13.4	0.532
Sexal(m/w)	10/5	6/2	
pathogenic level			
C3-4	1	0	
C4-5	4	2	
C5-6	7	5	
C6-7	3	1	

The clinical data of patients in two groups are shown in **Table 2**. The operation time and blood loss between the two groups was not statistically significant ($P > 0.05$). In both groups, the ESR gradually decreased after operation, and restored to normal at 3 months postoperatively. There was no significant difference between the two groups ($P > 0.05$). X-ray and/or CT examination showed that bone graft fusion were achieved in all cases. The mean fusion time was no significant difference between the two groups ($P > 0.05$). The postoperative local Cobb Angle increased in both groups compared with the preoperative value, and decreased slightly at the final follow-up. However, there was no statistical difference between the two groups ($P > 0.05$). Neurological outcomes of groups A and B are demonstrated in **Table 3**. Patients with ASIA grade B/C/D in the 2 groups improved 1 to 2 grades after the surgery. No significant statistical difference was found between the 2 groups postoperatively. The mean visual analog scale (VAS) for donor-site pain in group A was higher than group B at a week after surgery ($P < 0.05$). At the final follow-up, there was no significant difference between the two groups.

Table 2. The clinical data of patients in two groups

Characteristic	Group A(15 patients)	Group B(8 patients)	p
Surgical time	173.3± 20.8	179.8 ±46.4	0.631
Blood Loss (mL)	323.4 ±105.1	281.0 ± 84.2	0.336
Ambulation time(m)	6.7. ±1.4	3.8 ±0.8	0.000
Duration of follow-up	24.0 ± 5.7	25.8 ± 7.6	0.509
Fusion time(m)	4.3± 1.6	4.4± 1.4	0.917
ESR			
Preoperative	55.2±19.1	61.4 ± 19.5	0.170
Postoperative	21.8±9.9	26.8 ± 6.2	0.144
Final follow-up	11.4±6.3	13.5±4.3	0.371
Cobb			
Preoperative	18.1±8.2	16.3 ± 8.2	0.577
Postoperative	-2.4±2.6	-2.1 ± 2.8	0.746
Final follow-up	-1.0±2.2	-1.4 ± 2.5	0.732
VAS (donor-site)			
A week Post-op	3.4±0.9	2.3±0.9	0.005
3-months Post-op	1.6±0.7	1.1±0.7	0.070
Final follow-up	0.7±0.5	0.6±0.5	0.569
Complication(donor-site)	3	0	

Table 3 The neurological outcomes of patients in two groups

ASIA	Group A					Group B				
	A	B	C	D	E	A	B	C	D	E
Preoperative		1	2	8	4			3	5	0
Postoperative				2	13				1	7

In group A, there were three mild complications. A patient suffered from superficial wound infections at the donor site. It was treated successfully with oral antibiotics and dressing change. Two patients suffered from chronic donor-site pain, which was treated with many of the nonsteroidal drugs and markedly improved three months after surgery. In group B, no patient complained of donor site pain and narcotic pain medication was not required for donor site pain after discharge.

Discussion

Although the incidence of cervical tuberculosis is low, it tends to lead to vertebral destruction and abscess formation, which often resulting in quadriplegia because of the particular anatomical site. Conservative treatment often is unsuccessful, which require surgical intervention.

Anterior surgery has become the standard procedures for the treatment of cervical spinal tuberculosis because cervical tuberculosis mainly invades the spinal anterior column.[3] The procedure has the advantage of removing the focal point of the disease directly and its effective spinal cord and nerve decompression, with minor surgical invasion, and effective kyphosis correction. However, the large intervertebral gap creating by debridement always cause instability of the cervical spine. Therefore, the reconstruction of the anterior spinal column is necessary[14] .

Autologous tricortical bone grafts are widely used as the grafting materials for reconstructing the spine and are considered as the gold standard method because it provides an osteoconductive, osteoinductive, and osteogenic substrate for filling bone voids. Hassan et al[15]. reported the outcomes of 16 patients with cervical spinal tuberculosis who had anterior debridement, autogenous iliac bone grafting, and instrumentation. All cases had bony fusion and kyphosis markedly improved at the latest follow-up. Whereas, the donor site complication, such as pain at the donor site, nerve injury, hematoma, infection, and fracture, has been reported in up to 40% of cases.[4] The most common complication involved with the harvest of iliac bone is pain at the donor site. In Wael Koptan et al. study[16], the anterior column was reconstructed with an autogenous iliac bone graft in 14 patients with cervical tuberculous, and four patients had persistent pain at donor site and one patient had a large hematoma 35%. In our cohort, one patient suffered from superficial wound infections at the donor site and 2 patients occurred chronic donor site pain after surgery 20%.

To reserve the advantages of autogenous graft and minimize the donor site morbidities, sternal graft has been applied in anterior cervical fusion (ACF) procedures [9-12]. The cancellous bone harvested from sternal manubrium with an interbody cage was used for ACF, and the results show that the sternal manubrium provides a viable alternative to iliac bone grafting, which has advantages of autograft fusion, avoiding the complications associated with iliac crest graft harvesting[9-10].

In the present study, we have harvest a structural sternal autograft for anterior reconstruction of cervical spine. In our experience to date, the structural sternal autograft have the following advantages. First, it has a high osteogenic potential. In this group of 8 patients, all patients achieved satisfactory bone fusion. Second, both ACF and bone harvest was performed in a single operative field, which can save the time and labor needed to prepare separate sterile fields and reduce the chance of intraoperative pollution. Third, it has a low complication rate at donor site. In present study, there was not hematoma formation, infection, injury to the great vessels and pleura and chronic pain in group B, while 3 cases (20%) occurred donor site complications in group A. As we know, significant pain at the iliac donor site affects early getting out of bed. Patients who stay in bed for a longer time may easily lead to complications such as pneumonia and deep vein thrombosis. In contrast, there was no postoperative pain in the chest area to

the patients harvested bone from manubrium ,which allow to ambulate with a cervical collar after three days of the surgery.

We also found some disadvantages in structural manubrial autograft.We obtained the two-sided cortical bone, compared with the tricortical iliac crest,which may have insufficient supporting force and lead to fracture. However,no fractures were found in these 8 cases.which may be because we excluded elder patient with osteoporosis. Then,the amount of bone mass obtained was only adequate for reconstruction of bone defects within two segments, while the ilium crest could obtain longer bone mass.In addition,the visibility of the scar may affect the cosmetic result when wearing low-cut clothing. Therefore, it is advisable to avoid this method in young women or in patients who are particularly concerned with appearance.Last one,there are some potential risks in taking bone from the manubrium, such as the injury of the great vessels and pleura,so it is necessary to take advantage of piezosurgery to take bone because piezosurgery is a recent innovative technique that permits a selective cut of mineralized tissue while sparing soft tissues.

There are several limitations to this study.The sample size was small, which could not well explain the advantages of harvesting a structural bone from manubrium . In addition, because the follow-up time was short, the long-term effect of manubrial bone graft could not be determined and thus long-term follow-up is needed.

Conclusion

Anterior debridement,fusion and internal fixation for the treatment of lower cervical spine tuberculosis was effective and feasible. Both iliac bone grafts and sternal manubrium grafts can effectively reconstruct anterior column defects creating by completely clear the tuberculosis focus in anterior surgery. However,structural sternal manubrium autografts has less complications associated with donor site morbidities than that of iliac bone. Further study with a large number of cases and longer follow-up will be necessary.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of the Affiliated Hospital of Southwest Medical University.All patients provided written informed consent prior to their inclusion in this study.

All the methods were performed according to the appropriate guidelines and regulations.

Consent for publication

Not applicable.

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article. The raw data can be requested from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

study design,QW,SX,YMS; data collection,GJQ,JY; data analysis,SZ; writing original draft preparation, SX; prepared figures,SW,YLX.All authors have read and approved the final manuscript, and ensure that this is the case.

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Figures

Figure 1

a-b In the workstation, the breadths, height and thickness of manubrium were measured

Figure 2

A 46-year-old male patient with cervical spine tuberculosis(C5-6) a-c Preoperative radiography and MRI showed destruction of C5-6 vertebrae with kyphosis and spinal cord compression c X-rays showed reduction of cervical kyphosis after intraoperative traction d X-Ray demonstrated anterior debridement, iliac bone grafting and internal fixation from C4 to C7 e CT scan at 12 months of follow-up showed that bone fusion at the interface.

Figure 3

A 46-year-old male patient with cervical spine tuberculosis C5-6. a-c Preoperative radiography, CT and MRI showed significant cervical kyphosis, C5-C6 vertebral body destruction, epidural abscess formation and spinal cord compression. d Postoperative CT showed cervical kyphosis improved after anterior debridement, structural manubrium grafting and anterior plate fixation. e Radiography taken at 3 months of follow-up showed bony fusion was obtained at the graft-host junction. f CT scan at 12 months of follow-up showed that correction of kyphosis was maintained, and implants were in good position. g-h Postoperative 3D-CT show the scope of defect of the manubrium, which became smaller one year after operation.