ORIGINAL ARTICLE

Single stage anterior reconstruction using titanium mesh cages in neglected kyphotic tuberculous spondylodiscitis of the cervical spine

Wael Koptan · Yasser ElMiligui · Mohammad ElSharkawi

Abstract Cervical tuberculous spondylodiscitis is a serious, hazardous disorder and to our knowledge, hardly any reports focused on the use of titanium mesh cages in its treatment. The aim of this work is to evaluate the efficacy of using a titanium mesh cage compared to iliac crest grafting regarding correction of the deformity, fusion rate and to report the incidence of complications. A prospective, non-randomized multicentre study of 30 patients with cervical tuberculous spondylodiscitis presenting with a neglected kyphotic deformity. The average age was 44.5 years; 18 had neurological deficits. All patients had a single stage radical debridement, decompression, and instrumentation. The anterior column was reconstructed with a titanium mesh cage in 16 patients (Group 1) and an autogenous iliac bone strut graft in 14 (Group 2). Both groups were followed for a minimum of 2 years. Group 1 showed a better sagittal profile and local kyphosis was corrected from an average of 36° (10°–62°) to an average of −6° (+4° to −16°) compared to Group 2 corrected from an average of 30° (6°–48°) to an average of −1° (+2° to −13°). Group 1 patients showed a solid bony fusion without any recurrence of infection while Group 2 showed a higher incidence of nonunion and of persistent donor site morbidity. The use of titanium mesh cages effectively restores the sagittal profile while adding immediate stability. There is no donor site morbidity, recurrence, or persistence of infection associated with their implantation.

Keywords Titanium mesh cages · Tuberculosis · Spondylodiscitis · Cervical

Introduction

Tuberculous spondylodiscitis affects around 50% of all patients with musculoskeletal tuberculosis [1]. Tuberculous lesions often involve the intervertebral disc, the endplates of the adjacent superior and inferior vertebral bodies while the posterior column is usually spared; a kyphotic deformity is often the result of severe destruction of these elements [2]. This can result in serious, hazardous consequences, especially in the cervical spine due to its peculiar anatomy and inherent instability.

The main indication for surgical intervention is the presence of a neurologic deficit, which occurs in around 15–50% of tuberculous spondylodiscitis patients [3, 4]. Other indications include abscess formation [5], persistent or recurrent infection, severe pain [6], local kyphosis, and segmental instability [7].

Anterior cervical corpectomy offers the most direct approach for adequate decompression and effective stabilization and reconstruction of the cervical spine. Nevertheless, early construct failures of fusion performed using

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autograft and allograft struts and anterior plating have been reported to range from 6% up to 71% especially in multiple level corpectomies [8–10].

Titanium mesh cages have proven their effectiveness in the reconstruction and restoration of spinal column stability in trauma and tumor surgery [11, 12]. However, there is significant controversy regarding the use of these metal implants in the presence of active infection.

The aim of this study is to compare the efficacy of using a titanium mesh cage (TMC) compared to iliac crest grafting in tuberculous spondylodiscitis of the cervical spine regarding correction of the neglected kyphotic deformity, fusion rate and to report the incidence of complications.

Patients and methods

This multicenter study, approved by the Institutional Review Board and the ethics committee, included 30 patients with tuberculous spondylodiscitis of the cervical spine who gave their informed consent to be included in this research. All patients had radical debridement, decompression, anterior column reconstruction, and instrumentation. It consisted of a prospectively collected consecutive series of 16 patients (Group 1), treated between 2004 and 2007, who had reconstruction using a TMC, compared to an earlier series of 14 consecutive patients (Group 2), treated between 2000 and 2004, who had reconstruction using an autogenous iliac crest strut graft.

The study included 16 females and 14 males with an average age of 44.5 (range 22–71) years; Group 1 averaged 42 (22–68) years, while Group 2 averaged 44.5 (24–71) years ($P = 0.12$).

The diagnosis of tuberculous spondylodiscitis was based on clinical presentation, laboratory testing, and imaging findings. Immediately, thereafter, antituberculous treatment was started preoperatively.

All patients had the classic symptoms of tuberculosis including night fever, loss of weight, fatigue, neck pain; five patients previously received treatment for pulmonary tuberculosis. The duration of the disease averaged 2 years (range 11 months–4 years). A 10-point Visual Analogue Scale (VAS) was used to evaluate neck pain and the neurologic status was graded according to the Frankel [13] scoring system.

Laboratory testing included an elevated erythrocyte sedimentation rate (ESR 1st h) to an average of 94 mm/h (range 71–136 mm/h) and a positive C-reactive protein and tuberculin tests in all patients.

The radiographic assessment included preoperative standard anteroposterior and lateral views. All patients had a single level affection and the sagittal profile was measured by Cobb's method as the angle between the endplates above and below the infected level. Group 1 patients had an average kyphosis of 36° (range 10°–62°) while Group 2 had an average of 30° (range 6°–48°) ($P < 0.001$). There were five patients (16%) with non-adjacent affection of the dorsal or lumbar vertebrae. MRI revealed a paravertebral abscess in 9 patients (30%) and an epidural abscess with significant cord compression in 14 patients (46%).

Surgery was indicated for one or more of the following: the presence of a neurologic deficit, epidural abscess formation, local kyphosis with severe endplate destruction and intractable pain.

Surgical technique

All patients had a single-stage anterior radical debridement, decompression, correction, anterior column reconstruction, and instrumentation. Patients were placed in the supine position under general anesthesia and the cervical spine was exposed through an anterolateral approach. The inflammatory reaction can cause adhesions and distortion of the local anatomy; thus, careful surgical dissection was mandatory. Resection of all infected and necrotic disc and bony tissue was performed until healthy bleeding bone was reached on either side. Paravertebral and epidural abscesses were drained and decompression was meticulously performed until the spinal canal was cleared of any pus or infectious debris. Extreme caution was maintained during debridement near the vertebral artery and was performed by the gentle use of curettes and rongeurs. The local kyphotic deformity was corrected by gradual distraction using a Caspar distractor or an intervertebral body spreader.

In Group 1 patients, a TMC was inserted; it was appropriately tailored to achieve both sufficient stability and restore segmental cervical lordosis. The cage was packed with autogenous anterior iliac crest cancellous bone obtained through a small stab incision using a hollow trephine.

In Group 2 patients, the anterior column was reconstructed by a suitably fashioned tricortical iliac crest strut autograft.

In both groups, anterior plating extended one level above to one level below the affected vertebrae. Immediate stability was obtained without the need for supplementary posterior instrumentation.

Postoperatively, standard radiographs were obtained; a broad-spectrum cephalosporin was administered for an average of 7 days in addition to the antituberculous treatment, which was continued, for an average of 12 (range 9–14) months. All patients were placed in a Philadelphia cervical collar for 8–10 weeks and then gradually weaned off it over another 4 weeks.
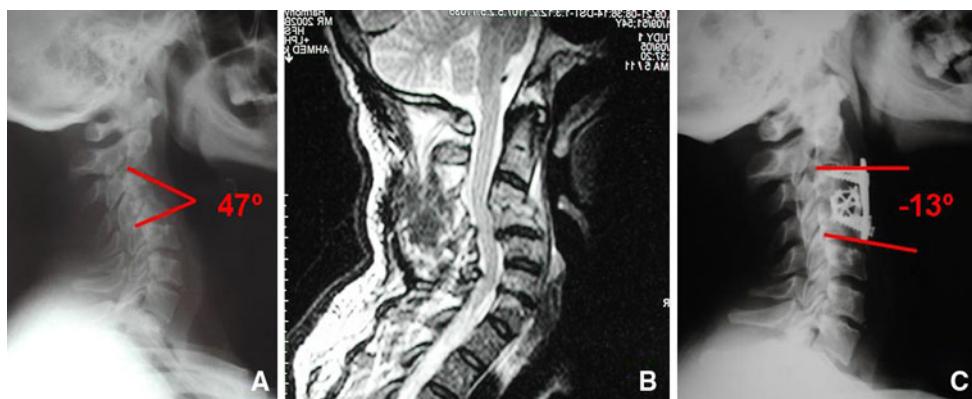
Follow-up Patients were followed for an average of 5.5 (range 2–7) years. All patients were viewed at 6, 12, 18, 24, 36 weeks and 1 year postoperatively and afterwards were followed up at yearly intervals. Clinical evaluation, laboratory tests, and plain X-rays were individually scheduled at each visit.

Results

The operative data were analyzed; the clinical and radiological results were evaluated and complications related to the surgical procedure were also reviewed.

Operative notes

The total operative time was significantly less in Group 1 with an average of 100 (range 70–115) min than Group 2 with an average of 125 (range 110–165) min ($P < 0.001$). The difference in blood loss was not significant with an average of 120 cc in Group 1 (range 105–145 cc) and 130 cc in Group 2 (range 115–160 cc) ($P = 0.09$). The average hospitalization time was 5 (range 4–7) days in Group 1 and an average of 6 (range 5–9) days in Group 2 ($P > 0.99$).

Clinical evaluation

It was performed at each visit to evaluate the amount of neck pain and neurological improvement. A 10-point Visual Analogue Scale (VAS) was used to evaluate neck pain which had an average preoperative scale of 8 (range 7–10) in Group 1 and an average preoperative scale of 8.5 (range 8–10) in Group 2 ($P = 0.15$). At the last follow-up, there was a significant difference in neck pain improvement to an average of 1.5 (range 0–2) in Group 1 to an average of 2.5 (range 0–4) in Group 2 ($P = 0.01$).

The preoperative neurologic status was graded according to the Frankel classification as 8 Frankel B, 10 Frankel C and 12 Frankel E patients. Sphincteric disturbances were found in five patients. At the last follow-up, 6 patients improved one grade, 7 patients improved two grades, 4 patients improved three grades and the neurologic status remained unchanged in 13 patients. No patients were neurologically worse after surgery including all the Frankel E patients. Sphincteric disturbances improved in 4/5 patients. There was no significant difference in recovery between Groups 1 and 2.

The necrotic debris removed was always sent for analysis (identification of the Mycobacterium and/or by PCR) which confirmed the diagnosis of tuberculosis. Laboratory follow-up included ESR and CRP measurement to detect the presence of active infection. In all patients, both decreased gradually postoperatively and returned to a normal level at an average of 12 (range 9–14) months after which antituberculous treatment was stopped.

Radiologically

Imaging studies were examined by an independent radiologist. Plain X-rays obtained preoperatively, immediate postoperatively and at the last follow up; were analyzed to detect sagittal plane correction, any implant failure and to assess fusion.

Group 1 showed a better sagittal profile; local kyphosis was corrected from an average of 36° (range 10°–62°) to an average of −6° (range +4° to −16°) at the last follow up (Fig. 1) compared to Group 2 which was corrected from an average of 30° (range 6°–48°) to an average of −1° (range +2° to −13°) ($P < 0.01$) (Fig. 2).

Fusion was assessed by the presence of bridging trabecular bone and absence of radiolucency at the junction between the graft/cage and opposing vertebra. On plain X-rays, Group 1 patients showed a solid bony fusion at the latest follow-up. There were no dislodgments or expulsions; mild settling of the titanium cage (of less than 2 mm) was found in four patients. There were no graft fractures or displacements observed in Group 2; nevertheless there was a higher incidence of nonunion (2/14 patients).

Fig. 2 A 51-year-old female with C5/6 affection and reconstructed by an iliac crest autograft. **a** Pre-op X-rays with a 37° kyphosis, **b** pre-op MRI, **c** final correction to 3°
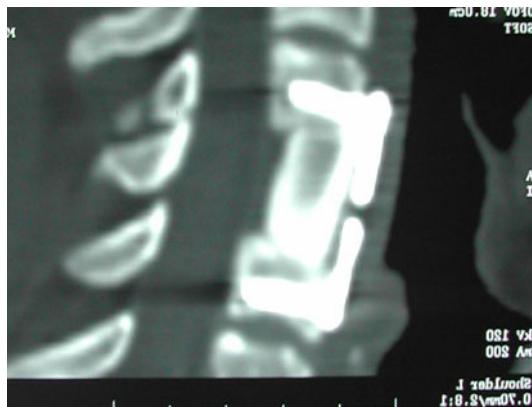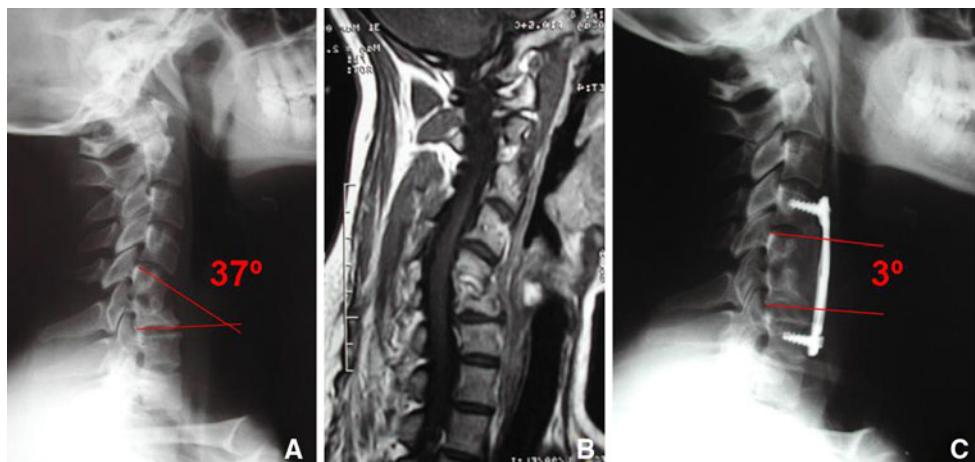
Fig. 3 A 32-year-old male with C4/5 affection; CT scan showing solid fusion at 3 years follow-up

Due to several difficulties, a CT scan was performed for only 18 patients; however, due to the presence of an abundant metal artifact; solid fusion could not be confirmed except in 14 patients (Fig. 3). In the remaining 12 patients, flexion/extension views were performed to confirm the presence of fusion.

Complications

Group 1

Two patients had superficial wound infections at the primary surgical wound and were successfully treated by antibiotics.

Group 2

Five patients had donor site morbidity: four patients had persistent pain and one patient had a large hematoma requiring drainage.

Two patients had a nonunion and loss of correction that was 12° and 18°, respectively; both patients had a single level discectomy initially performed which was revised into a full corpectomy and a longer tricortical iliac crest graft and plate were used. Both patients eventually united.

Discussion

Tuberculous spondylodiscitis results in destruction of the anterior and middle columns and a consequent kyphotic deformity, which can damage nearby neural elements [14]. The cervical spine has a peculiar anatomy and inherent instability, consequently spondylodiscitis in that region is a serious, hazardous disorder.

In 1960, Hodgson and Stock [3] reported the efficacy of anterior debridement and interbody fusion; however, debridement could result in large anterior defects and consequent instability. Stand-alone autografts failed to maintain sagittal plane alignment, with consequent loss of correction and development of progressive kyphosis as reported by Kemp et al. [15] using rib grafts with an average increase in kyphosis of 20°, a 32% incidence of rib graft fracture and an overall fusion rate of 62%. Similar results were reported latter by and the larger the defect following debridement, the higher was the incidence of graft failure [16, 17].

The use of anterior instrumentation improved both the maintenance of spinal alignment and graft incorporation. Several authors reported on anterior debridement, fusion and instrumentation in different regions of the spine with encouraging results with high fusion rates and kyphosis correction ranging from 64 to 86% with no significant loss of correction [18–20].

Very few authors particularly focused on the surgical management of cervical spine infections; Hassan [21] reported the results of 16 patients with cervical spine tuberculosis who had anterior debridement, autogenous iliac bone grafting, and instrumentation. All cases had bony

fusion and kyphosis improved from an average of 21.6° preoperatively to an average of 2.5° at the latest follow-up.

In our series, tricortical iliac crest grafts supplemented by anterior instrumentation were used in 14 patients. It maintained effective correction of the kyphotic deformity from an average of 30° (range 6°–48°) to an average of −1° (range +2° to −13°). The use of anterior instrumentation added stability which allowed adequate graft incorporation. Although there were no iliac crest graft fractures or displacements; there was a comparatively high incidence of nonunion as 2 patients required regrafting.

Iliac crest donor site morbidity has serious postoperative concerns for both patient and surgeon. Long-term patient complaints may be more associated with harvesting of the graft rather than the primary surgical site. Donor site complication rates as high as 10% minor and 9% major have been reported after autogenous bone grafting. Most importantly, chronic donor site pain has been reported in up to 40% of cases [22, 23].

In this study, five patients, where a tricortical iliac crest graft was harvested, had donor site morbidity; four patients had persistent pain and one patient had a large hematoma requiring drainage. These complications were avoided in the TMC group, as we used a hollow trephine through a stab incision to obtain cancellous bone to fill the cages.

The effectiveness of TMC was established in treating several spinal disorders including fractures, tumors, and deformities [24–26]. On the other hand, placement of instrumentation in the setting of a spinal infection has been controversial. Lee et al. [27] affirmed that titanium cages have gained acceptance in reconstructive surgery performed in the setting of concomitant infection. The differences of adherence and biofilm formation between *S. epidermidis* and *Mycobacterium tuberculosis* were evaluated on various spinal implant surfaces. Significantly less bacterial adherence, multiplication, and biofilm formation was found with *M. tuberculosis* compared to *S. epidermidis* indicating less resistance to the host defense mechanisms and antituberculous chemotherapy, which provide the basis for successful implantation and instrumentation in tuberculous lesions [28].

It is important to realize that previous studies [24–26] included the overall results of collectively reported miscellaneous cervical spine pathologies including trauma, degenerative disorders, and tumors. To our knowledge, no previous study focused on the use of TMCs in the treatment of patients with tuberculous spondylodiscitis of the cervical spine.

Kuklu et al. [29] reported a series of 21 consecutive patients with pyogenic vertebral osteomyelitis treated with titanium mesh cages. There were no cervical spine affections and the study included six thoracic, four thoracolumbar, nine lumbar and two lumbosacral lesions. The most common pathogen was *Staphylococcus aureus*. All patients had resolution of infection, as noted by normalization of the ESR and CRP and 16/21 patients had a significant reduction of pain. The average segmental kyphosis was 11.5° preoperatively and +0.8° at latest follow-up with an average of 2.2 mm cage settling. There were no instrumentation failures, signs of chronic infection or rejection.

Later, Korovessis et al. [30] presented 24 patients suffering from persistent septic spondylitis treated by a single stage combined surgeries; first, anterior debridement/partial vertebrectomy plus mesh cage filled with autologous bone graft; second, pedicle screw fixation with open and minimal invasive techniques. The VAS score improved from 6.5 to 1.8 after surgery. The segmental kyphotic deformity was corrected at an average of 6° without cage settling. All operated patients had resolution of infection. There was neither migration of mesh cage nor posterior instrumentation failure at the last follow-up.

Most recently, Lu et al. [31] reported the results of the surgical treatment of osteomyelitis with expandable titanium cages and either allograft or autograft with only 7/36 patients having cervical spine affections. The most frequently identified organisms were *Staphylococcus aureus*, *Mycobacterium tuberculosis*, and *Coccidioides immitis*. Most patients who had an anterior approach also underwent posterior instrumentation. At follow-up, neurological deficits improved in all patients, and 81% of patients were pain-free.

In the present study, tuberculous spondylodiscitis of the cervical spine had radical debridement, decompression, anterior column reconstruction, and instrumentation. The defect was reconstructed using a TMC in 16 patients (Group1). In this group, a better sagittal profile was achieved as local kyphosis was corrected from an average of 36° to an average of −6° at the last follow up. Compared to Group 2, the total operative time was significantly less; on the other hand, the difference in blood loss, hospital stay, and neurological recovery was not significant.

The presence of a paravertebral abscess or an epidural abscess with significant cord compression did not seem to affect the final clinical or radiological outcome; neither did the period the patient has been diagnosed with spinal tuberculosis and administered antituberculous treatment.

In most patients, a single level discectomy was performed and enough bone was preserved from the superior vertebral body to provide adequate cage stability and anchorage for the plate screws. On the other hand, a complete corpectomy was occasionally the end result in five patients in each Group, thus the authors did not believe that this will affect the overall outcome.

This procedure ensured immediate correction of the preoperative kyphotic deformity and restoration of stability

with no need for supplementary posterior instrumentation. Radical debridement must not have restrictions; and regardless of the size of the resultant defect, immediate stability was restored by TMCs which are available in variable lengths and diameters. The implantation of TMCs resulted in solid bony fusion with no dislodgments or expulsions; mild settling was found in only 4 patients.

Conclusion

The use of TMCs supplemented by anterior plating provided a mechanically sound construct which maintained correction throughout the period of follow up. Filling these cages with cancellous bone graft harvested through a stab incision eliminated the incidence of donor site morbidity. There were no complications from implanting TMCs in the presence of tuberculous infection which was eradicated in all patients.

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