Neurological recovery in patients of old healed tubercular rigid kyphosis with myelopathy treated with transpedicular decancellation osteotomy

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Abstract

Purpose The purpose of the study was to find out if transpedicular decancellation osteotomy (TDO) is recommendable for neurological recovery in patients with myelopathy due to tubercular rigid kyphosis. We have analyzed the pattern of recovery seen after the surgery and also made an effort to correlate the neurological recovery with preoperative clinical and radiological features.

Methods The clinical parameters used were (1) ASIA impairment scale for motor and sensory function, (2) sphincter dysfunction score, (3) time duration from the onset of myelopathy till the date of surgery, and (4) SRS 30 outcomes questionnaire. Radiological parameters used were (1) Cobb's angle in standing/sitting radiographs, (2) levels of gibbus, (3) cord changes in sagittal T2 MRI images, and (4) percentage of cord compression. Assessment was done preoperatively and at 1 month, 3 months, 6 months, 1 year and at 2 years postoperatively.

Results Seventeen patients were included. The follow-up period was 2 years. We had one patient in ASIA A, nine patients in ASIA C and seven patients in ASIA D. Four patients with ASIA C presented with mild sphincter disturbance (score 2) and one presented with severe disturbance (score 1). The ASIA A patient had complete retention (score 0). The ASIA impairment scale improved after surgery, with maximum improvement at 3 months and improvement continuing up to 6 months. 16 (94 %) patients had improvement in lower limb function and 5 (83 %) patients had improvement of sphincter function. 94 % patients had neurological recovery after the operation. The neurological recovery reached a plateau at

6 months with no significant improvement in the further follow-up. Preoperative MRI changes, cord compression and duration from onset of myelopathy to day of surgery were not predictive of the final neurological outcome after surgery.

Conclusion TDO gives good results in delayed onset neurological deficits in caries spine with rigid kyphosis. At least, one grade improvement in the neurological status of patients with ASIA C and ASIA D can be expected. Maximum improvement in the neurology is seen in the first 3 months and up to 6 months from the date of surgery, without much improvement thereafter.

Level of evidence Level IV.

Keywords Tuberculous · Kyphosis · Neurological recovery · Transpedicular decancellation osteotomy

Introduction

Neurological deficits can develop in tuberculous (TB) spine in active as well as healed stage of the disease. Treatment of neurological deficits in active stage is well defined but treatment of delayed onset neurological deficit in healed disease is still a subject of debate. Nearly, 3 % of patients with TB spine develop severe kyphotic deformity which also needs correction [1]. It is clear that there is no role for conservative treatment in these patients. Surgical correction has been attempted through both anterior and posterior approaches. Anterior decompression surgeries have shown inconsistent neurological improvement and the deformity correction is also not satisfactory [2–4]. Single-stage posterior surgeries such as vertebral column resection, closing–opening wedge osteotomy, transpedicular decancellation osteotomy (TDO) and Pedicle Subtraction

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Osteotomy have all shown excellent correction of deformity with variable improvement in the neurological deficits [5–9].

The pattern of recovery, grades of improvement in motor power to be expected after surgery, relation with severity of neurological deficits, time period to show improvement, time period after which improvement plateau and many other questions still remain to be answered. In this study, we have attempted to answer these questions in patients of old healed tubercular rigid kyphosis with myelopathy treated by TDO with internal gibbectomy. We have also tried to find if neurological recovery shows any relation with preoperative neurological status, preoperative imaging and preoperative duration of the deficit.

Materials and methods

Seventeen consecutive patients suffering from delayed onset neurological deficits due to rigid kyphotic deformity who underwent TDO at a tertiary referral spine centre were included in the study. All the patients were followed up and their follow-up data for 2 years from the date of surgery were taken up for the study. The diagnosis was made based on history, clinical signs and symptoms and investigations, which included radiographs of the spine standing/sitting—anteroposterior and lateral, magnetic resonance imaging of whole spine and blood investigations. Active infective foci were ruled out.

Totally, 93 patients underwent surgery for post-tubercular neurological involvement. We have included only those in whom myelopathy signs were first seen at least after 2 years of healing of the disease and in those cases which showed compression on the cord due to an internal gibbus with a rigid kyphotic deformity. Acute cases, those in whom neurological deficits started before 2 years, and those cases where deficits were due to causes other than internal gibbus were excluded from the study, which brought down the number to 17. The average age was 21 years (9–36 years). None of these patients was known immunocompromised. None of them had any history of HIV/organ transplant/drug abuse or other chronic illness.

The clinical parameters used were (1) ASIA impairment scale for motor and sensory function, (2) sphincter dysfunction score, (3) time duration from the onset of myelopathy till the date of surgery, and (4) SRS 30 outcomes questionnaire.

Radiological parameters used were (1) Cobb's angle in standing/sitting radiographs, (2) levels of gibbus, (3) number of levels involved, (4) levels of cord changes in T2 MRI images, and (5) percentage of cord compression.

All these patients underwent TDO by the senior author at the same centre.

Surgical technique

Patients were put in prone position under general anaesthesia. Pedicle screws were put three levels up and three levels down followed by laminectomy up to three levels at the apex of deformity. A temporary rod fixation was done on one side. Transpedicular decancellation was done on both sides shifting the temporary rod as required. Internal gibbectomy was done for complete anterior decompression. Under contoured permanent rod was put, using cantilever principle for correction of deformity. Anterior column support with a cage was given when required. Figure 1 shows a case where deformity correction was done without a cage and Fig. 2 shows a case where cage was used. Final rod was inserted and apical compression given. Morselized local bone graft was placed posterolaterally. No preoperative or postoperative anti-tuberculosis medications were given to any of these patients. No neurotrophic medications were added in the postoperative period.

Follow-up was at 1 month, 3 months, 6 months, 1 year and yearly thereafter. We have included only those patients who had come for a minimum follow-up of 2 years in this study. Statistical analysis was done with Student's *t* tests. *p* values less than 0.05 were regarded as statistically significant.

Results

All the 17 patients were available for follow-up. The results were analyzed by independent observers.

Clinical Outcomes

ASIA impairment scale for motor and sensory function assessed before surgery and in the postoperative period is given in Table 1. Most number of patients showed improvement in their first 3 months. In the first month, one grade improvement was seen in one patient with ASIA C and two patients with ASIA D. In the third month follow-up, six patients in ASIA C and six patients in ASIA D improved by one grade and additionally one patient with ASIA C at presentation improved to ASIA E, i.e., 2 grades. All the ASIA D patients had improved to ASIA E by 3 months but only one patient in ASIA C improved to ASIA E. At 6 months follow-up, one grade improvement was shown by two patients and two grades improvement was shown by three patients in ASIA C. At the end of 6 months, out of the total nine ASIA C patients four of them improved to ASIA E and five improved to ASIA D. Although some minor improvements were noted after 6 months they did not qualify enough to be called an

Fig. 1 Preoperative and postoperative radiograph of a patient who presented with ASIA C and 102° curve. He improved to ASIA D neurologically with a decrease in curve to 60°

improvement to a better grade. For practical purposes, their neurological improvement plateaued after 6 months and in the next one and half years it remained the same.

Bladder dysfunction was scored using the JOA score for bladder dysfunction. Those presenting with complete retention were marked as score 0. Those with severe disturbance which included (1) inadequate evacuation of bladder, (2) straining, and (3) dribbling of urine were given score 1. Those with mild disturbance which means (1) urinary frequency, (2) urinary hesitance were given score 2 and a score 3 for normal patients.

Complete retention (score 0) was present in one patient with ASIA A. She remained the same in the postoperative follow-up. Severe disturbance (score 1) was present in one patient with ASIA C. She showed good results in first month follow-up but plateaued later with mild disturbance (score 2) persisting. Mild disturbance (score 2) was present in four patients with ASIA C at the time of presentation. In the follow-up, one patient showed improvement by 3 months and two others improved by 6 months to regain normal sphincter function (score 3) but one patient remained the same. The remaining patients did not show any significant sphincteric dysfunction. We could only reach at a conclusion

that in those presenting with mild disturbance of sphincter dysfunction improvement can be expected by 6 months but in those presenting with severe disturbance or complete retention much should not be expected. The number of patients with bladder disturbance is low in our series and hence a larger series is required to reach specific conclusions. The detailed chart is given in the Table 2.

Time duration from the onset of myelopathy of these patients was correlated with the recovery pattern of their neurology. The time duration from the onset of myelopathy symptoms as noted by the patients, the neurology with which they presented and the final outcome are given in Table 2. It was noted that the progression of neurology in these patients was not time related, i.e., there were patients in whom the myelopathic symptoms had remained status-quo for longer time without deterioration and there were patients in whom it had deteriorated fast. However, preoperative duration of myelopathy when taken into account along with the preoperative neurological status is of value in predicting the postoperative recovery. Longer duration of myelopathy with worse neurological status at the time of surgery gives poor postoperative neurological recovery as in the case with ASIA A patient.

Fig. 2 Preoperative MRI and radiograph of a patient who presented with ASIA C and 84° curve. He improved by one grade to ASIA D and final curve measurement was 46°

Table 1 Preoperative and the follow-up ASIA impairment scale

Patient	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ASIA Preop	A	C	C	D	C	D	D	C	D	D	C	C	C	C	D	D	C
1 month	A	C	C	E	C	D	D	C	D	D	C	C	D	C	E	D	C
3 months	A	C	C	E	D	E	E	D	E	E	D	D	E	D	E	E	D
6 months	A	D	D	E	E	E	E	E	E	E	D	D	E	E	E	E	D
1 year	A	D	D	E	E	E	E	E	E	E	D	D	E	E	E	E	D
2 years	A	D	D	E	E	E	E	E	E	E	D	D	E	E	E	E	D

Bold represent one grade improvement, bold italics represent two grade improvement and italics represents no improvement from preoperative status

SRS 30 outcomes questionnaire was used to score the other parameters like the pain relief, patient satisfaction and improvement in function. SRS 30 outcomes questionnaire takes into consideration the function, pain, image, mental health and satisfaction. Significant improvement in the *p* value is seen in the function, self image and satisfaction domains at their 2-year follow-up. Table 3 shows the SRS scores of these patients.

Radiological outcome

The average preoperative Cobb's angle was 69.3° which improved to 30.1° in the immediate postoperative radiographs, showing an average improvement of 38.2° (55 %). This improvement of about 38° brings down the kyphosis of the thoracic spine well within the normal range of 20°–40° and helps to attain a good sagittal balance. The most

Table 2 Preoperative neurology, preoperative sphincter dysfunction score, duration from the diagnosis of myelopathy, apex of deformity, preoperative Cobb's angle, percentage of cord compression, levels of changes in T2 image MRI, postoperative neurology at 2 years, postoperative sphincter score at 2 years and postoperative Cobb's angle

Pt	ASIA preop.	Sphincter score	Duration of myelopathy	Apex of deformity	Preop Cobb's angle (°)	Cord compression (%)	Levels of T2 changes	ASIA@ 2 years	Sphincter score@ 2 years	Postop Cobb's angle (°)
1	A	0	4 years	D7	52	80	9	A	0	18
2	C	1	2 years 4 months	D12	84	70	6	D	2	46
3	C	2	2 years 6 months	D10, 11	102	80	9	D	3	60
4	D	3	2 months	D11	82	50	4	E	3	42
5	C	3	6 months	D4, 5	60	70	4	E	3	13
6	D	3	3 months	D8–9	42	20	3	E	3	14
7	D	3	3 months	D5	46	30	3	E	3	20
8	C	2	8 months	D5	72	50	6	E	3	34
9	D	3	1 month	D7, 8	66	20	6	E	3	34
10	D	3	4 months	D10, 11	42	40	5	E	3	26
11	C	3	9 months	D6	96	80	10	D	3	36
12	C	2	11 months	D9–10	78	60	9	D	2	30
13	C	3	1 year	D10, 11	68	60	7	E	3	22
14	C	2	2 years 1 month	D10	100	80	6	E	3	42
15	D	3	4 months	D7	56	30	3	E	3	18
16	D	3	6 months	D5–6	62	40	4	E	3	28
17	C	3	1 year 4 months	D8	70	50	3	D	3	28

Table 3 SRS preoperative and at 2-year follow-up postoperatively along with their *p* value

Variables	Preoperative	Postoperative	Improvement	<i>p</i> value
Function	2.48	3.64	1.16	0.005
Pain	3.10	4.52	1.42	0.007
Image	2.67	3.76	1.09	0.005
Mental health	3.18	3.87	0.69	0.008
Satisfaction	1.9	4.5	2.60	0.005

Table 4 Extent to which the spinal cord is compressed at the level of maximum deformity by <25, 25–50, 50–75 and >75 % and the extent of T2 signal changes in MRI as >6, 3–6 and <6 vertebral levels

Cord compression	ASIA A	ASIA C	ASIA D
>75 %	1	3	
50–75 %		6	1
25–50 %			4
<25 %			2
Extent of cord changes			
<3		1	3
3–6		5	4
>6	1	3	

common level of gibbus was between D8 and D11. The most common type was paradiscal with involvement of two adjacent vertebral bodies. We could not find any relation between site and the levels of involvement with postoperative neurological recovery. The details are shown in Table 2.

Preoperative MRI was studied to understand the spinal cord changes if they correlate with postoperative neurological recovery. The amount to which the cord is compressed at the level of maximum deformity and T2 signal changes in the cord were considered. For better understanding, we classified patients as those having >75 %, 50–74 %, 25–49 % and those having less than 25 % cord compression. ASIA A and ASIA C patients had compression more than 50 %, whereas those presenting with ASIA D were having less than 50 % except one patient. The number of levels involved was divided as 0–3, 3–6 and >6 levels. The data are summarized in Table 4.

Notable factor was those with ASIA D had comparatively lesser levels of involvement than ASIA C patients. But all the ASIA D and ASIA C patients have shown at least one grade of improvement and four of the ASIA C patients have shown two grades of improvement. This led us to conclude that neither the amount of cord compression nor the number of levels of T2 signal changes in MRI is predictive of the neurological outcome in these patients.

Discussion

Tuberculosis is still a common disease in Africa and South East Asia. Nearly, 3 % of patients with TB spine develop severe kyphotic deformity. Severe post-tubercular kyphosis is more than a cosmetic disfigurement as most of these patients develop cardiopulmonary dysfunction, painful impingement between ribs and pelvis and compression of the spinal cord with paraplegia at an average of 10 years after the onset of the disease [1]. Achieving recovery of neurological deficits and correction of kyphosis in healed disease is difficult. Jain has suggested that patients with tuberculosis of the spine who are likely to have severe kyphosis ($>60^\circ$) on completion of treatment should undergo surgery in the active stage of disease itself to improve kyphus [10]. Rajasekaran has also suggested surgery in active stage, in those who have the radiological signs which predict late increase in deformity to prevent late onset neurological deficits, in his study on the natural history of post-tubercular kyphosis in children [11]. These studies stress upon the importance of preventing kyphosis and late onset neurological deficits because the treatment for the same has not shown good results till recently. It is clear that conservative treatment does not have any role in the recovery of such patients and literature on recovery of such late onset neurological deficits after surgery is also sparse.

Surgical options for severe post-tubercular kyphosis include both anterior and posterior procedures. Anterior procedures for late onset neurological deficits can be divided into two types; those in which deformity correction was attempted and those in which no attempt was made at deformity correction. Hsu et al. have operated on eight patients with healed disease by anterior decompression. One patient with severe paraplegia recovered completely, two others with moderate paraplegia were unchanged and two improved slightly. Two minimal cases had total recovery. They have concluded that in patients with healed disease, the anterior decompression is technically more difficult and recovery less satisfactory [2]. One of their patients took 24 months to show recovery. We took a minimum follow-up of 2 years as this is the maximum time that we could find in literature showing any neurological recovery in late onset tuberculosis.

A midterm clinical result of anterior decompression and grafting without any attempt for correction of the kyphotic deformity was published by Bilsel et al. They have operated on eight patients and all of them have shown some neurological improvement [3]. Rangachari in 2008 published his results on eight patients operated for paraplegia of late onset in adolescents with healed childhood caries of dorsal spine. All his patients were subjected to anterior spinal decompression via transthoracic, transpleural thoracotomy. Two

patients with grade 3 power recovered in 6 months to grade 4 power, four patients with grade 2 power recovered to grade 4 in about 8 months, and two patients with grade-0 power recovered to grade 4 power in about a year. But no deformity correction was done in these patients. All patients were treated postoperatively with neurotrophic medicines, such as pyridoxine and methyl cobalamine [4]. We have not used any specific medications for neurological recovery. These studies on anterior procedures show neurological improvement in some patients, but the deformity correction is uniformly not very encouraging.

Simultaneous anterior decompression and posterior instrumentation for acute neurological deficits in tuberculous spine using an anterolateral extrapleural approach by Jain and single-stage decompression, anterior interbody fusion and posterior instrumentation of the dorso-lumbar spine described by Laheri VJ have both shown excellent results for neurological recovery [12, 13]. But whether a similar procedure is safe and shows improvement in late onset neurological deficits needs to be studied further.

Posterior only surgeries for correction of kyphotic deformities and decompression of the spinal cord are done in different ways by surgeons around the world. Posterior vertebral column resection, Closing–opening wedge osteotomy, TDO and pedicle subtraction osteotomy are among the common procedures. The results of posterior vertebral column resection (PVCR) as published by Suk, who described the procedure, appears to be a good option as far as deformity correction is concerned but then complications in 24 patients out of their total 70 make it a very demanding procedure. Two of these patients had complete cord injuries and four root injuries [5]. We feel such exhaustive procedures, as described by Suk himself, may not be ideal for those patients with neurological deficits as any minor insult to the already compromised cord can deteriorate their neurology further. TDO possibly is safer than PVCR though deformity correction is less.

Rajasekaran et al. in their study on single-stage closing–opening wedge osteotomy to correct severe post-tubercular kyphotic deformities of the spine had 3 Frankel D and 2 Frankel C patients. Their results show that three recovered to Frankel E and one improved to Frankel D and were able to walk. This procedure has given excellent results in deformity correction and also the 1 patient in their series who deteriorated neurologically was due to a malpositioned screw and not by the basic technique of the procedure [6]. Gokce et al. published their results in 2008 on spinal osteotomy for correction of sagittal balance in tubercular spondylitis. They have done decompression and closing wedge osteotomy and posterior instrumented fusion. Out of the total 12 patients operated, four had neurological deficits and they have shown improvement in three. One patient with ASIA C did not improve. Kyphotic

deformity of the patients has improved from 51.1 to 23.2° postoperatively [7].

Kalra et al. has described their results in 15 post-tubercular kyphotic deformities treated with pedicle subtraction osteotomy. They have excluded patients who presented with neurological deficits. They did 11 egg shell osteotomies and four total vertebral resections and were able to achieve a correction of 44.2° on an average without any postoperative neurological deficit in any of the patients [8]. Bezer has shown TDO to be a safe and reliable technique in the treatment of post-tuberculosis kyphosis. Their results on 16 patients with 5-year follow-up have shown significant correction in kyphotic angle and restoration of sagittal balance without radiologic correction loss in any of the patients during follow-ups. There was no neurologic deterioration in any of their cases [9]. We also now firmly believe that TDO is a safe procedure and can be used with confidence in those patients who are already neurologically compromised. In our series, out of the 17 patients 16 have shown improvement in their neurology. Only the patient with ASIA A, who had neurological deficit for 4 years, did not show improvement. Out of the six patients with sphincter dysfunction, three became normal by 6 months.

Preoperative duration of neurological deficit when treated separately did not help in predicting postoperative recovery in our patients. This is because neurological deterioration did not show uniform progression. There were patients in whom myelopathic changes have remained the same without further deterioration for long time and there were patients in whom it had progressed faster. However, those with severe deficits and longer duration did not show good recovery. Moon et al. in 2003 have reported on seven patients with healed tuberculosis treated for severely deformed dorsal or dorsolumbar spines. They have concluded that patients with paralysis persisting over 6 months did not recover neurologically after surgery. Two of their patients underwent anterior surgery and five underwent posterior surgery. None of them has shown improvement except for a child. One Frankel A and one Frankel B paraplegic patients who had paralysis that had lasted through 6 months did not recover after surgery [14]. We feel that these two patients did not improve because of the severity of deficit and not due to duration. In our series, preoperative duration did not determine recovery, as in our study patients those who were diagnosed to have paraparesis even 2 years before surgery presenting with ASIA C have improved.

TDO gives reasonably good correction of Cobb's angle. We had an average correction of 38.2° which brought the postoperative angle within the normal range of thoracic kyphosis. Literature on single-stage posterior surgeries uniformly show good results for kyphosis correction whether it is vertebral column resection, closing–opening

wedge osteotomy, TDO or Pedicle Subtraction Osteotomy [5–9]. The results are very impressive and we believe that these posterior surgeries have the potential to replace anterior procedures as far as kyphosis correction is concerned. The preoperative and last follow-up SRS scores in our study show high improvement in patient satisfaction, which is a very important factor in deformity surgeries.

MRI is now the standard investigation for patients with neurological deficits. We have tried to correlate the preoperative MRI findings with their neurological recovery after cord decompression. Studies on MRI changes in cord with other pathologies like cervical spondylotic myelopathy and traumatic injuries cannot be applied directly to patients with post-tubercular rigid kyphosis [15, 16]. Dunn et al. have reported on MRI scans of 82 consecutively managed spinal tuberculosis patients over a 4-year period. They have found correlation between residual cord size, cerebrospinal fluid remaining anterior to the cord, presence of cord signal changes in the T2-weighted images, and neurologic deficit; however, none was predictive of outcome [17]. Sai Kiran et al. [18] in their study on neurological recovery on acute spinal TB patients also could not correlate the final outcome with the cord changes in MR imaging and the number of vertebral levels involved. Jain has shown that the magnitude of thinning of cord did not always correlate with severity of neural deficit; however, thinning of cord in association with myelomalacia carried a bad prognosis in patients with active disease [19]. All these studies are on acute stage disease. Our study is on patients with late onset neurological deficit and in these patients also T2 image hyperintensity changes and the percentage of cord compression did not show any relation with postoperative neurological outcome.

The number of patients with sphincter dysfunction in this study is less and hence the improvement pattern and surgical outcome in this regard cannot be generalized. Preoperative T2 image changes in MRI, percentage of cord compression and preoperative duration of myelopathy were not predictive of the final neurological outcome. Possibly including more preoperative clinical and imaging parameters could have helped in finding out a correlation with the postoperative recovery pattern. These are our study limitations.

Conclusion

TDO is a safe procedure which gives excellent results for neurological recovery in delayed onset neurological deficit in old healed tuberculous spine. Maximum recovery in the neurology is seen in the first 3 months and up to 6 months improvement can be expected. At least one grade improvement in the neurological status of patients with

ASIA C and ASIA D is seen. Improvement in sphincter dysfunction can be expected up to 6 months but as our number is less in this regard, we suggest further studies before reaching a definitive conclusion. Preoperative T2 image changes in MRI and percentage of cord compression were not predictive of the final neurological outcome. Preoperative duration of myelopathy when taken into account along with the preoperative neurological status is of value in predicting the postoperative recovery.

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