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Anterior Radical Debridement and Reconstruction Using Titanium Mesh Cage for the Surgical Treatment of Thoracic and Thoracolumbar Spinal Tuberculosis: Minimium Five-Year Follow-Up

Anterior Yoldan Radikal Doku Debridmanı Yapılan ve Titanyum Ağ Kafesler ile Omurga Rekonstrüksiyonu Yapılan Torakal ve Torakolomber Omurga Tüberkulozu Olan Hastaların Beş Yıllık Takipleri

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ABSTRACT

AIM: To evaluate the long-term outcomes for the surgical treatment of thoracic and thoracolumbar spinal tuberculosis with anterior radical debridement and reconstruction with titanium mesh cages (TMCs).

MATERIAL and METHODS: 69 patients with thoracic and thoracolumbar spinal tuberculosis were retrospectively analyzed. Outcomes data included VAS back pain, subjective clinical results, and radiographic data.

RESULTS: All patients had resolution of their infections, obtained solid bony fusions without failure of fixation, experienced improvement of neurological function, and improved in their VAS back pain scores at final long-term follow-up. In the thoracic spine group, 92.3% of patients had good or excellent subjective clinical results. The loss of kyphotic angle correction and intervertebral height was 9.6% and 3.8%, respectively. In the thoracolumbar spine group, 93.3% of patients had good or excellent subjective clinical results. The loss of kyphotic angle correction and intervertebral height was 12.8% and 4.2%, respectively.

CONCLUSION: Anterior radical debridement and reconstruction using TMCs for the treatment of thoracic and thoracolumbar spinal tuberculosis is an acceptable treatment option. Solid bony fusion, good clinical outcomes as well as improvement of neurological function can be achieved although TMCs subsidence can occur.

KEYWORDS: Thoracic spine, Thoracolumbar spine, Tuberculosis, Debridement, Titanium mesh cage, Fixation

ÖZ

AMAÇ: Anterior yoldan radikal doku debridmanı ve titanyum ağ kafesler ile omurga rekonstrüksiyonu yapılan torakal ve torakolomber omurga tüberkulozu olan hastaların uzun dönemli sonuçları ele alınmıştır.

YÖNTEM ve GEREÇLER: Torakal ve torakolomber omurga tüberkulozu olan 69 hasta geriye dönük olarak incelendi. Serinin verileri görsel ağrı ölçütlemesi, bel ağrısı, sübjektif klinik sonuçlar ve radyolojik bulgular şeklinde gruplandırıldı.

BULGULAR: Tüm hastaların enfeksiyonu tedavi edildi ve sağlam ve güçlü bir kemik füzyonun elde edilmesi yanı sıra, nörolojik fonksiyonları düzeldi, görsel ağrı ölçütlemesinde bel ağrıları azaldı. Torakal grubda hastaların %92.3'de mükemmel sübjektif klinik sonuçlar alınırken, bu oran torakolomber spinal grupda % 93.3 oldu. Kifotik açının düzelmesi ve vertebralar arası yüksekliğin yeniden kazanılması sırası ile %12,8 ve %4,2 olarak bulundu.

SONUÇ: Torakal ve torakolomber Spinal tüberkuloz hastalarında anterior yolda yapılan debridman ve titanyum ağ kafesler ile yapılan rekonstrüksiyon işlemi kabul edilebilir bir tedavi yöntemidir.Hastalarda iyi klinik sonuçlar ve nörolojik düzelme elde edilmiş olmasına rağmen titanyum kafeslerde gömülme (subsidence) meydana gelmesi olasılığı vardır.

ANAHTAR SÖZCÜKLER: Torakal omurga, Torakolomber omurga, Tüberkuloz, Debridman, Titanyum ağ kafes

INTRODUCTION

In recent years, the incidence of tuberculosis (TB) has increased rapidly around the world along with resistance of the organism (1). In 2002, data from the Ministry of Health of China showed that the active pulmonary TB prevalence was 367 /100,000, and the incidence of drug resistant infections was 10.7% (19). Between 1% to 3% of extrapulmonary tuberculosis occurs in the skeletal system with spinal involvement up to 50%. (6,28) Spinal TB can cause collapse of vertebra, kyphotic deformities and neurological deficits. Delayed diagnosis and treatment of pulmonary TB, or spinal TB can result in high morbidity rates. (16) Surgical treatment of spinal TB utilizing anterior radical debridement combined with antituberculosis chemotherapy is an accepted method of the treatment of spinal TB. (13,29) Large intervertebral defects can occur after anterior debridement, and surgical stabilization of the spinal segments is often necessary. Iliac crest or fibula bone autografting are two widely used techniques for the reconstruction of such bony lesions. However, the morbidity can be high, including severe pain in the surgical area and lower extremity dysfunction. Late complications include bone graft dislodgement, fracture, resorption, subsidence and recurrence of kyphosis. (2,26).

In order to mitigate the morbidity of autograft, anterior radical debridement with placement of titanium mesh cages (TMCs) has been used to treat thoracic and thoracolumbar spinal tuberculosis or pyogenic infection.(5,11,17) Some authors, (7,27) however, note significant subsidence of the construct postoperatively. To date, there are few studies analyzing whether cage subsidence can affect spinal alignment, fusion rates, and clinical outcomes. In this study, we conducted a long-term follow-up study of 69 patients with thoracic and thoracolumbar spinal TB who underwent anterior radical debridement, reconstruction with TMCs and fixation. We hypothesize that although subsidence can occur with TMCs, good clinical and radiological outcomes can still be achieved at final follow-up.

MATERIAL and METHODS

Population and Clinical Presentation

After approval was obtained from our Institutional Review Board, 69 patients with thoracic and thoracolumbar spinal TB were retrospectively analyzed from March 2002 to March 2005. All patients exhibited chest and back pain, weight loss, moderate fever and fatigue, and there were no cases of acute miliary pulmonary TB. All patients underwent dual energy X-ray absorptionetry (DEXA) scans, and patients with severe osteoporosis were not included in this study. No patients had destruction of more than two contiguous motion segments. Patients were divided into two groups according to the anterior fixation. In thoracic spine group, a single-rod system was used for the lesions at the level of T10 or above. There were 22 males and 17 females with average age of 38.6 years (18 to 66 years) in this group. There were 15 patients who had neurological deficits due to the compression of spinal cord, with Frankel Grade B in 2, C in 5 , and D in 8. The mean preoperative focal kyphosis was 43.6° with a range of 38° to 50°. The average intervertebral height ranged from 95.4mm to 115.3mm with a mean of 96.1mm. In thoracolumbar spine group, a dual-rod system was used for the lesions below T10, and in this group there were 16 males and 14 females with average age of 36.5 years (19 to 63 years). There were 12 patients who had neurological deficits due to the compression of spinal cord, with Frankel Grade B in 2, C in 4, and D in 6. The mean preoperative focal kyphosis was 21.5° with a range of 18.6° to 27.6°. The average intervertebral height ranged from 90.5mm to 125mm with a mean of 109.4mm.

All patients underwent standard anti-tuberculosis chemotherapy through oral administration for a minimal length of two weeks before surgery and lasted 9 to 12 months after surgery. For the patients who had no neurological deficits or fever, the medical therapy regimen included isoniazide (300mg per day), rifampicin (450mg per day), ethambutol (1200mg per day), and intramuscular streptomycin (750mg per day). For the patients who had neurological deficit or fever, the chemotherapy regimen included isoniazide (300mg per day) intravenously, rifampicin (450mg per day), ethambutol (1200mg per day), and intramuscular streptomycin (750mg per day).

Surgical Procedure

Under general anesthesia, the patients were placed in lateral decubitus position. All patients underwent thoracotomy or thoracoabdominal approaches and radical debridement for thoracic and thoracolumbar spine TB. The discs were removed above and below the resected vertebrae while preserving the bone endplates. If the patient had bilateral paravertebral or psoas abscess, supplementary surgical drainage of the abscess was performed. Anterior decompression of spinal canal was performed until the dura appeared devoid of compression. Gram stains, tuberculosis and common bacterial cultures were performed.

Anterior reconstruction with the TMCs (Depuy-Acromed,USA) was performed in all patients. A surgical assistant manually applied pressure to correct the kyphotic angle and the length of the titanium mesh cages was measured (2-3mm longer than resected gap). The bone grafts were selected according to the surgical approach. For thoracic group, the resected ribs combined with allograft bone were used to fill the cage. For thoracolumbar group, the cage was loosely filled with allograft bone and then placed into the lesion zone under fluoroscopic guidance.

Anterior instrumentation then placed to maintain structural stability. Anterior fixation was selected according to the main level of the destruction of vertebrae and disc. Given the increased stability in the thoracic spine afforded by the orientation of the thoracic facet joints (20) and rigidity of the ribcage, we performed the single-rod titanium-alloy fixation (Ventrofix, AO, Synthes, Switzerland) in 39 patients in the level of T10 or above. However, we consider levels below T10 to be

within the anatomical transition zone from the thoracic to lumbar spine, so double-rod fixation was selected to maintain thoracolumbar spine stability. In this group, there were 17 cases using Ventrofix (AO, Synthes, Switzerland) and 13 cases using ISOLA (Depuy-Acromed, USA).

Follow-up Evaluation

All cases were seen at one week, 3, 6, 9, and 12 months after surgery and annually thereafter. Clinical data included the perioperative parameters, intra - and post-operative complications. The visual analogue scale (VAS) was performed preoperatively, 3 months postoperatively and at final follow-up. Subjective clinical results were categorized as excellent, good, fair, and poor. Excellent was defined as satisfaction with the surgery with no residual symptoms and a return to previous activities. Good was defined as improved symptoms with occasional need for analgesics, fair was defined as dissatisfaction with the surgery with residual symptoms, and poor was defined as dissatisfaction with the surgery with worsened symptoms. The resolution rate of TB infection was based on Mehta's research: (21) No recurrence of infection was noted within six months post-surgery.

Radiological examination included plain radiographs for all patients. Measurements were performed preoperatively, immediately postoperatively, and at final follow-up. The evaluation of focal kyphosis is shown in Figure 1A,B: (1) The angle of kyphosis and scoliosis was measured on the lateral and anteroposterior radiographs using the Cobb angle between the first normal vertebra above the lesion and the first normal vertebra below the lesion; (2) Intervertebral height was defined as the vertical height between superior and inferior vertebral body in coronal plane with fusion zone. The evaluation of osseous fusion on final radiographs was performed using the anterior and posterior fusion criteria described by Bridwell. (3)

Student's t-test was used for the comparison of statistical data (SPSS 17.0 for Windows, Inc, Chicago, IL, USA). Statistical significance was established at a p-value less than 0.05.

RESULTS

In the thoracic spine group (Figure 2A-F), the average follow-up period was 6.1 years (5.0- 7.2 years). The mean operative time was 177 minutes with a range of 120 to 240 minutes. The mean blood loss was 860 ml (550-1100 ml). No intraoperative complications were observed. Two patients developed superficial wound infections postoperatively, and all healed after debridement. One patient developed transient intercostal nerve pain that spontaneously resolved one week after operation. For VAS back pain, there was a statistically significant difference at 3 months after surgery compared with preoperative (1.4 vs 7.1, P<0.001), and final follow-up compared with 3 months after surgery (1.1 vs 1.4, P<0.001). For subjective patient-reported outcomes, excellent results were obtained in 30 patients, good in 6, fair in 2 and poor in 1, with 92.3% of patients having a good or excellent result. The preoperative average kyphosis angle was reduced from 43.6° to 29.3° postoperatively and was 33.5° at final follow-up. The loss of Cobb angle correction rate was 9.6%. The preoperative intervertebral average height increased from 96.1mm to 105.5mm immediately postoperatively, and was 101.3 mm at final follow-up. The loss of intervertebral height was 3.8%. No scoliosis developed in this group (Table I). One patient had obvious TMCs subsidence 5 years after surgery with a decrease of intervertebral height of 11mm and an increased in kyphosis of 3° (Figure 2A-F). 15 patients with neurological deficits improved one grade or more at final follow-up.

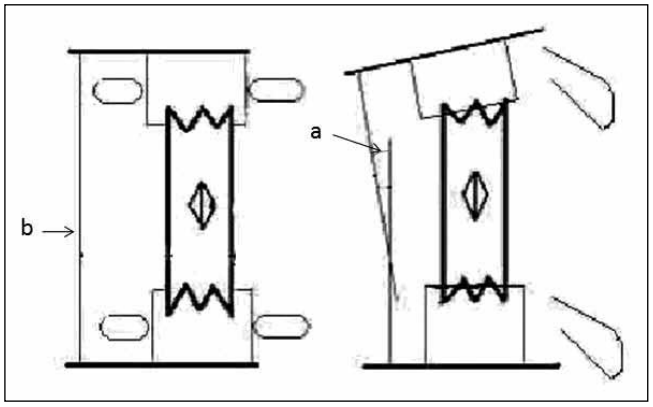

Figure 1: A) Kyphosis angle of fusion segment; **B)** The vertical height of the fusion segment (mm).

In the thoracolumbar spine group (Figure 3A-H), the average follow-up period was 6.0 years (5.0 - 7.1 years). The mean operative time was 160 minutes with a range of 120 to 220 minutes. The mean blood loss was 890 ml (570-1200 ml).

Table I: The Average Angle of Kyphosis (°) in Thoracic and Thoracolumbar Spine Group

Index	Preoperative	Postoperative	Final Follow-up	Loss of Correction
Thoracic Group	43.6	29.3	33.5	9.6%
Thoracolumbar Group	21.5	6.5	9.2	12.8%

Table II: The Average Intervertebral Height (mm) in Thoracic and Thoracolumbar Group

Index	Preoperative	Postoperative	Final Follow-up	Loss of Intervertebral Height
Thoracic Group	96.1mm	105.5mm	101.3mm	3.8%
Thoracolumbar Group	109.4mm	121.2mm	115.8mm	4.2%

There were no intraoperative complications. Postoperative complications included a superficial wound infection in one patients healed after surgical debridement, and one patient with a chylous leak. The leak was treated by stopping oral intake, total parenteral nutrition, and placement of a drain. The chylous leak ceased and the drain was removed on postoperative day 10. One patient was found to have a retroperitoneal empyema and a nonhealing wound two weeks postoperation. Further treatment with debridement and antituberculosis chemotherapy achieved complete healing after two weeks. For VAS back pain, there was a statistically significant difference at 3 months after surgery compared with preoperative (1.5 vs 7.4, P<0.001), and final follow-up compared with 3 months after surgery (1.1 vs 1.5, P<0.001). For subjective patient reported outcomes, excellent results were obtained in 24 patients, good in 4, fair in 1 and poor in 1, with 93.3% of patients having a good or excellent result. The preoperative average kyphosis angle was reduced from 21.5° to 6.5° immediately postoperatively and 9.2° at final follow-up. The loss of Cobb angle correction rate was 12.8%. The preoperative intervertebral average height increased from 109.4 mm to 121.2 mm immediately postoperatively and 115.8mm at final follow-up for a loss of intervertebral height rate of 4.2% (Table II). These patients developed an average scoliosis of 12° (5-16°). One 63 year-old patient with mild osteoporosis, T12/L1 spinal tuberculosis and upper endplate destruction of L2 vertebra developed lateral displacement of the cage 6 years after operation; the intervertebral height decreased 16mm and the kyphosis angle increased by 6°. The scoliotic angle was 16°. 12 patients with neurological deficits improved at least one grade at final follow-up.

All patients in both groups resolved their infections according to the Mehta's standard. All patients achieved solid bony fusions without fixation failure at final follow-up.

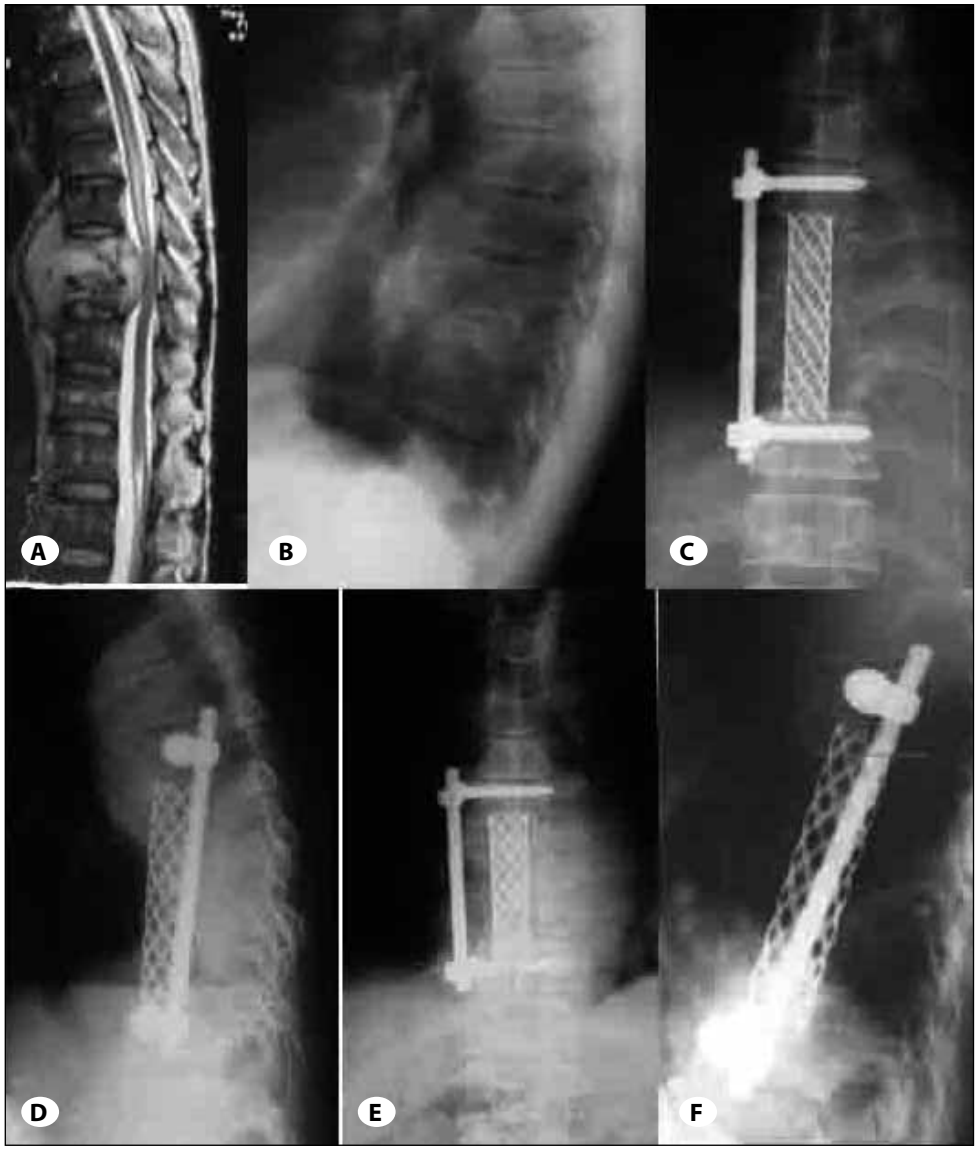

Figure 2: Films of a 47-year-old female. **A)** Preoperative MRI revealed obvious destruction of T8 and T9 with partial involvement of T10. Also notable are paravertebral and epidural abscesses with concomitant compression of the spinal cord. **B)** X-ray revealed the destruction of the ninth vertebra with a pathological fracture and narrowing of the T9-10 disc space. **C)** and **D)** Immediate postoperative radiographs demonstrating anterior radical debridement, placement of a titanium mesh cage T7-11 and single-rod anterior instrumentation. **E)** and **F)** X-rays taken 5 years after surgery demonstrate subsidence of the cage 4mm into the cephalad endplate and 7mm into the caudal endplate with a decrease of 11mm in intervertebral height, and an increase in kyphotic angle of 3°.

Figure 3: 63 year-old male with T12/L1 spinal tuberculosis and mild osteoporosis. **A)** and **B)** Preoperative MRI revealed destruction of the T12 and L1 vertebra, a large left psoas abscess and epidural abscess causing compression of spinal cord. **C)** and **D)** Immediate postoperative radiographs demonstrating anterior radical debridement, placement of a titanium mesh cage T11-L2 and dual-rod anterior instrumentation. **E)** Immediate postoperative MRI revealed adequate decompression of the spinal cord. **F)** and **G)** Plain radiographs at 6 years revealed subsidence of the cage 3mm into the cephalad endplate and 13mm into the caudal endplate with a decrease of intervertebral height of 16mm and an increase in kyphotic angle of 6°. The scoliosis was measured at 16°. **H)** Sagittal CT reconstruction demonstrated a solid fusion around the cage.

DISCUSSION

Frequently, spinal TB often involves two or more vertebral levels in the thoracic or thoracolumbar spine. Radical debridement and decompression are the standard procedures for the surgical treatment of spinal TB, but the stability of the spine can be significantly compromised after creation of a large intervertebral gap. Reconstruction of the anterior spinal column is commonly needed. In the early days of surgical treatment of spinal TB, autograft strut bone graft alone without fixation (13) was an accepted method of

treatment due to concerns of instrumentation affecting the ability to irradicate infection. Risk of bone graft dislodgement led to immobilization with a body cast or bed rest for months at a time. More recently, studies have shown that the ability of mycobacterium to adhere to metal instrumentation is lower than staphylococcus. (14,22) Good results have since been achieved using autograft bone combined with anterior or posterior fixation. (8,15,23,30) Some studies, however, (2,18,26) have shown a high percentage of fracture and migration using autograft iliac crest and autograft fibula strut with concomitant disadvantages including extra surgical time for harvest, more blood loss, harvest site pain and potential disability from fibular harvest.

Multiple studies (4,9,25) have demonstrated the effectiveness of using TMCs for interbody fusions. Roberston, (27) however, treated 31 patients who had undergone spinal reconstruction using TMCs for acute fractures, post-traumatic deformity, neoplastic disorders and infection, and observed that there was a high rate of complications using cages; one patient developed asymptomatic cage fracture, two patients with complex three-dimensional deformities experienced construct failure, and some cages were placed in an angulated position. Dvorak reported on 53 patients treated by with TMCs reconstruction. (7) Subsidence of the cages at the cephalad and caudal endplates averaged 0.28 and 0.20 cage fenestrations, but overall spinal sagittal alignment was not affected and 93% achieved radiographic osseous union.

In this study, the loss of angular correction and intervertebral height occurred in all patients and was associated with cage subsidence. Two patients experienced significant subsidence. Additionally, in the thoracolumbar spine group development of scoliosis angle was also noted secondary due to obvious cage subsidence.

With regard to the causes of cage subsidence, Grant et al. discussed several potential factors to explain cage subsidence or displacement. (12) One of their primary reasons is the penetration of the cage teeth into the endplates, especially in the face of osteoporosis. Additional reasons include non-ideal cage placement, suboptimal cage length, lack of supplemental fixation, and premature mobilization.

Our long-term follow-up indicated that kyphosis correction and restoration of intervertebral heights can still be adequately maintained in each region of the spine using these constructs. At the final follow-up, there were no failures of instrumentation. Solid bony fusion, good clinical outcomes as well as improvement of neurologic function were achieved in all patients.

Two main factors can potentially contribute to successful surgical outcomes. First, in order to avoid significant cage subsidence, preservation of the integrity of endplates is paramount. PMMA can also being used to reinforce the fixation. In the later cases of this study, we added an additional cage ring to increase the contact area between cage and endplate. Second, proper selection of supplemental instrumentation can effectively prevent cage-based failure. Based on the increased stability in the thoracic spine afforded by the orientation of the thoracic facet joints (20) and by the rigidity of the ribcage, single-rod titanium-alloy anterior fixation can be used to stabilize the thoracic spine zone. The advantages of this include less cost and less technical demand. In the thoracolumbar spine, we selected a dual-rod construct to stabilize the zone of resection because a single-screw single-rod construct can allow the vertebrae to rotate around the screws. (10) Oda et al has demonstrated higher construct stiffness and less rod–screw strain in the thoracolumbar spine with a dual-rod system. (24)

There are several limitations to this study, namely being a retrospective, non-randomized project. Also, no additional cage rings were used in early cases to prevent cage subsidence. We hope to conduct future studies to analyze the correlation between radiographic and clinical results in a larger case-control series.

CONCLUSIONS

Anterior radical debridement and reconstruction using titanium mesh cages is an acceptable surgical option for the treatment of thoracic and thoracolumbar spinal TB. Subsidence of the cages is not uncommon and results in the loss of Cobb angle correction and intervertebral height. Solid bony fusion, good clinical outcomes as well as improvement of neurological function can, however, be achieved with appropriate selection of anterior instrumentation.

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