

Posterior Transpedicular Intercorporeal Impaction Morselized Bone Graft for the Treatment of Pyogenic Thoracolumbar Spondylodiscitis a Prospective Cohort Study

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Abstract

Study Design: Prospective cohort study.

Objectives: To assess the efficacy of transpedicular intercorporeal impaction morselized bone graft in management of pyogenic thoracolumbar spondylodiscitis.

Methods: Patients were treated from 2013 to 2020. All patients underwent transpedicular anterior column debridement, intercorporeal fusion using morselized bone graft with posterior pedicle screw fixation. Kirkcaldy-Willis criteria and the Visual analogue scale for back pain were used. Neurological state was assessed by recording ASIA scale. Radiological fusion was assessed by the Brantigan and Steffee grading system. The local kyphosis angle was assessed preoperatively, postoperatively and at final follow up. The presence of any complications was reported

Results: 38 patients met our inclusion criteria. Patients mean age 55.26 ± 7.41 SD years and mean follow up 42.12 ± 11.35 SD months. Preoperative VAS for back pain significantly improved. Kirkcaldy-Willis functional outcome were excellent in 26 patients, good in 9 patients and fair in 3 patients. All neurologically affected patients showed improvement of their neurological status. Radiologically intercorporeal bony fusion grade 4 and 5. Preoperative local kyphotic angle significantly improved from mean $22.73^\circ \pm 4.85$ SD to $4.53^\circ \pm 2.35$ SD postoperatively and $5.75^\circ \pm 1.66$ SD at final follow up. No recurrence of infection, implant failure nor graft resorption.

Conclusion: Transpedicular debridement and impaction intercorporeal morselized bone graft is simple, safe, and cost-effective technique in treating thoracolumbar pyogenic spondylodiscitis. With good clinical and radiological outcomes.

Keywords: Spinal Infection; Impaction Morselized Bone Grafting; Posterior Spinal Approach; Transpedicular Intercorporeal Fusion

Introduction

Spinal infection represents 2-7% of all musculoskeletal infection [1,2]. The incidence of blood borne pyogenic spondylodiscitis was 1:100,000-1:250,000 [3,4]. Recently increase in the incidence due to increase in the number of the aging population, increased life expectancy, and presence of MRI as better diagnostic imaging modality [5]. The mortality rate ranges from 2 to 17% [3,5,6]. The

anterior spinal elements (vertebral body and disc are affected in 95% of haematogenous spondylodiscitis) while the posterior elements affected in 5% [5,7]. The lumbar spine is the most affected site (45-50%), followed by the thoracic region (35%) then the cervical (3-20%) and sacral regions [5,7]. It is mainly affecting population of 50-70 years [5], due to the associated medical comorbidities like diabetes mellitus, chronic renal failure, long term steroid use,

malignancy, malnutrition, liver cell failure and ischaemic heart disease.

Surgical intervention indicated after failure of conservative treatment, progressive neurological deterioration, bony destruction with segmental malalignment or instability and epidural abscess. Surgically the target is debridement, stabilization and reconstruction of the anterior column aiming for solid fusion. Different approaches have been described anterior, posterior, or combined approaches. Single or staged surgery each has its pros and cons [8-10]. The posterior spinal approach via the transforaminal approach in the lumbar spine, costotransversectomy approach in the thoracic spine are commonly used with difficult part in the technique which is the insertion of a structural graft or cage from the posterolateral approach because of the smaller operative field and the path of the nerve roots especially in the lumbar and thoracolumbar junctional regions. In the dorsal spine we may sacrifice nerve root with risk of myelon manipulation or spread of infection in the nearby neural structure.

In this study, reconstruction of the anterior spinal defect after debridement was done by using impacted morselized local and iliac bone graft mixed with antibiotic powder through the transpedicular approach together with posterior spinal fixation. We propose it is a safe, effective method, avoids neural tissue manipulation and decrease incidence of interbody graft dislodgment by maintaining the integrity of the posterior annulus.

Patients and Methods

A prospective study was done after approval from the institutional ethical committee .38 patients with blood born pyogenic spondylodiscitis of the thoracolumbar (from D10 to L2 levels) met our inclusion criteria.

One- stage instrumented posterior transpedicular debridement , impaction of morselized local and iliac bone graft through the transpedicular approach from April 2013 to March 2019. With mean follow up 42.12 ± 11.35 SD months. Inclusion criteria included adult patients with pyogenic spinal infection of the thoracolumbar regions. Indications for surgery included failure of conservative treatment, significant bony endplate destruction with resulting instability or deformity and neurological deficit. Exclusion criteria included post discectomy discitis, infected spinal implant, Tuberculous infection, cervical spine infection.

Preoperative diagnosis based on proper history taking, clinical examination, laboratory, and radiological investigations. Plain x rays, MRI, and C.T scan were done for all patients. Pre and post operative neurologic state were assessed by using the American Spinal Injury Association score (ASIA) [11]. Pre and postoperative Subjective back pain analysis were assessed by the visual analogue scale (VAS). Functional outcome was assessed by the Kirkaldy - Willis's criteria [12]. Radiologically, patients were assessed for fusion and loss of reduction including loss of the sagittal alignment and the intervertebral height.

Radiographic data focusing on the local kyphosis angle (LKA) Of the affected segment [13]. The intervertebral height of the involved segment was measured (Figure 1). Segmental collapse was defined as the difference between the intervertebral heights immediately postoperatively and at final follow up after bone graft consolidation. Fusion was assessed using Brantigan and Steffee fusion grading system (Table 1) [14]. Operative time, estimated blood loss, hospital stay, radiological and clinical Complications, loss of kyphosis correction, hardware failure, Bone graft resorption, residual and or recurrence of infection were recorded.

Grade 1	Unfused	Obvious radiographic Pseudarthrosis based on collapse of the construct, loss of disk height, vertebral slip, broken screws, cage displacement.
Grade 2	Probable unfused	Probable radiographic pseudarthrosis based on significant resorption of the bone graft, or a major lucency or gap visible in the fusion area.
Grade 3	Uncertain	Bone graft is visible in the fusion area at approximately the density originally achieved surgically. A small lucency or gap may be visible involving a portion of the fusion area with at least half of the graft area showing no lucency between the graft bone and vertebral bone.
Grade 4	Probable fused	Bone bridges the entire fusion area with at least the density originally achieved intraoperatively. No lucency between the donor bone and vertebral bone should be present.
Grade 5	Fused	The bone in the fusion area is radiographically denser and more mature than originally achieved intraoperatively. No lucency could be detected between the graft bone and cage with vertebral bone.

Table 1: Brantigan and Steffee fusion grading criteria.

Figure 1: A 55 years male submitted with chronic insistent back pain of further than three months, and failure to g unsupported walking owing to pyogenic spondylodiscitis disturbing D12 and L1 vertebrae. He was neurologically intact. Pre-operative AP , lateral X-rays Coronal , sagittal CT scan , sagittal and axial MRI illustrate marked destruction and collapse.

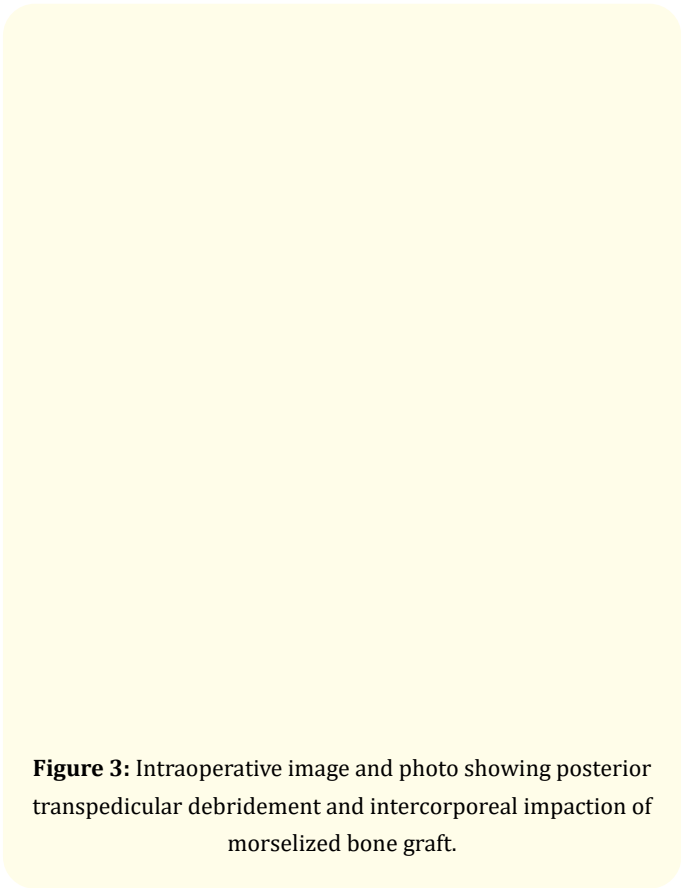
Figure 2: A ,B Immediate Post-operative AP and lateral X-rays after posterior debridement and transpedicular intercorporeal impaction morselized bone graft spanning the D12-L1 interval and pedicle screw stabilization. C ,D Two-year follow-up AP and lateral X-rays.

Operative technique

After prone positioning and trajectory identification, posterior midline incision, the planned levels were dissected and image intensifier to confirm index level is used. Transpedicular approach to the affected disc is used for debridement and impaction bone graft application (Figure 2). we start by pedicle probe then using small curettes to establish our working corridor in the pedicle caudal to the affected intervertebral disc. Through cephalic angulation in the sagittal plane the centre of the disc can be reached without violating the confinements of the pedicle to the disc. We substantially impulse the reach of the intended discectomy level be from the more caudally placed, adjacent pedicle. Access through a more cephalad pedicle has the potential of penetrating into the inferior borders of the pedicle and compromising the exiting nerve root.

We use curettes and disc Rongeur to debride, saline irrigation was done, and 8 mm funnel tube is used to apply our morselized graft after debridement. (Figure 3) Laminotomy or laminectomy were done if the patient has epidural collection aiming to decompress the neural structures.

Image intensifier is used all through the procedure to avoid destroying the anterior longitudinal ligament. Pedicle screws application were done after debridement to decrease the incidence of screw contamination. Screw application in the index level is done when possible. The screws should fill two third of the vertebral body. Locally harvested Bone graft with or without additional iliac Bone graft according to the size of the defect was morselized and impacted through funnel to reconstruct the anterior Column. Rod application is done according to the desired sagittal alignment.



Slight compression was applied posteriorly to correct local kyphosis. Haemostasis and posterolateral graft application were done. Standard wound closure with suction drain insertion.

Trans pedicular tissue Biopsy for culture and sensitivity tests were harvested intraoperatively. Postoperatively, as tolerated using Thoracolumbar soft brace, patients started early mobilization in the 1st postoperative day. Rehabilitation was started from day 2 postoperative for all patients. Patients were on empirical intravenous antibiotics till the results of culture and sensitivity.

Statistical analysis

Sample size calculations were completed former to the research, and case series research of at least 32 patients was detected to be suitable to check potential results. Statistics was studied using SPSS (Statistical Package for Social Sciences) version 15. Qualitative statistics was offered as number and percent. Wilcoxon signed ranks test was utilized for comparison within group. Quali-

tative statistics was offered as mean ± SD and range (min - max). Paired t-test was utilized for comparison within groups. P < 0.05 was statistically significant.

Results

38 patients, 25 male and 13 female met our inclusion criteria. Patients mean age 55.26 ± 7.41 SD years and mean follow up 42.12 ± 11.35 SD months. Preoperative VAS for back pain significantly improved from 8.29 ± 1.1 SD to 4.23 ± 0.52 SD postoperatively and 2.03 ± 0.64 SD at last follow up. Kirkcaldy-Willis functional outcome were excellent in 26 patients, good in 9 patients and fair in 3 patients. All neurologically affected patients showed improvement of their neurological status.

Co-morbidities were present in 65% of patients (Table 2). Diabetes mellitus (D.M), in 15 patients, chronic liver disease in 5 patients, chronic renal failure on dialysis in 2, breast carcinoma in 1, I.V drug abuse in 3, ischaemic heart disease in 3, Bronchial asthma on steroid inhalation in 2 patients, and local corticosteroid injection for back pain in 3 patients.

Age (years)	55.26 ± 7.41 SD (Range 33 - 72)
Sex	
Male	No. 25 (65.8%)
Female	No. 13 (34.2%)
Total	No. 38 (100%)
Level	
Thoracolumbar Junction	No. 38 (100%)
Co-morbidities	
Diabetic	No. 15 (39.5%)
Hepatic	No. 5 (13.15%)
Chronic renal failure	No. 2 (5.3%)
IV drug abuser	No. 3 (7.9%)
Breast Caner	No. 1 (2.63%)
Chronic heart disease	No. 3 (7.9%)
Chronic obstructive lung disease	No. 2 (5.26%)
Local steroid injection	No. 3 (7.9%)

Table 2: Demographic data and co-morbidities.

Severe Back pain was the presenting symptoms in all patients and Neurological deficit was present in 5 patients. The mean operative time was 149.73 ± 17.18 SD minutes (range, 115 - 195 min.)

The mean amount of blood loss was 715.32 ± 218.34 SD ml (range, 600 - 1450 ml). Average hospital stay was 5.3 ± 1.73 SD (range, 3-8) days (Table 3). 5 patients required postoperative I.C.U admission for observation over night. 32 patients (84.21%) had positive cultures Staphylococcus aureus in 9 patients, methicillin-resistant staph aureus (MRSA) in 5 patients, staph. Epidemidis in 2 patients, Streptococci in 7 patients, Escherichia coli (E coli) in 3, Pseudomonas aeruginosa in 3 and Klebsiella pneumoniae in 3 patients. 6 patients (15.79%) had no growth cultures after 48 hours.

FU (months)	46.12 ± 11.35 SD (Range 22 - 56)
Operative time (min)	149.73 ± 17.18 SD (Range 115 - 195)
Blood loss (ml)	400.32 ± 248.34 SD ml (Range 320 - 1400)
Hospital stays (days)	5.3 ± 1.73 SD (Range 3 - 8)
Duration of antibiotic (weeks)	11.67 ± 1.73 SD (Range 8 - 16)
Time to fusion (months)	8.92 ± 1.36 SD (Range 7 - 11)
ESR return	11.53 ± 1.49 SD (Range 9 - 15)
CRP return	6.47 ± 1.68 SD (Range 4 - 10)
Function results	
Excellent	No. 26 (68.4%)
Good	No. 9 (23.7%)
Fair	No. 3 (7.9%)

Table 3: Surgery related parameters, duration of antibiotic use, time to fusion, ESR and CRP return and overall clinical results.

Preoperative ESR was 68.27 ± 19.11 SD (range, 49 - 100) and the mean C- reactive protein (C-RP) level was 41.13 ± 26.34 SD (range, 34 - 108). C- RP normalized within an average of 12.47 ± 2.68 SD (range, 8-20) weeks postoperatively. ESR levels became normal within an average of 24.53 ± 2.49 SD (range, 20 -33) weeks. The total duration of antibiotic use was 11.67 ± 1.73 SD (range, 8 - 16) weeks.

Preoperative local kyphotic angle significantly improved from mean $22.73^\circ \pm 4.85$ SD (range, 17 - 27°) to $4.53^\circ \pm 2.35$ SD (range, 1 - 7°) postoperatively and $5.75^\circ \pm 1.66$ SD (range, 4-8 $^\circ$) at final follow up. Loss of correction was $1.4^\circ \pm .69$ SD (range, 1-3 $^\circ$). Radiologically within 8.92 ± 1.36 SD (range, 7-11) months, 30 patients had grade 5 and 6 patients had grade 4 fusion. The average inter-vertebral heights were 5.30 cm ± 0.78 SD (range, 4.6-6.4 cm), 6.0 cm ± 0.68 SD (range, 5-6.6 cm), and 5.6 cm $\pm .64$ SD (range, 4.8-6.5 cm) preoperatively, immediately postoperatively and at last follow up respectively. (Table 4) The average height loss was 0.5 cm ± 0.93 SD (range, 0.2 - 0.5 cm) showing only 6.2% rate loss. No recurrence of infection, implant failure, graft retropulsion.

Clinically Preoperative VAS for back pain significantly improved from 8.29 ± 1.1 SD (range, 7 - 10) to 4.23 ± 0.52 SD (range, 2 - 5) postoperatively and 2.03 ± 0.64 SD (range, 0 - 2) at last follow up. (Table 4) Kirkcaldy-Willis functional outcome were excellent in 26 patients, good in 9 patients and fair in 3 patients. All neurologically affected patients showed improvement of their neurological status. Preoperatively, there were 8 patients ASIA C, 10 D and 20 E. At the end of follow up, there were 33 patients ASIA E and only 5 patients ASIA D. (Table 4) Functional outcome based on the Kirkcaldy - Willis criteria at the end of follow up, showed excellent results in 26 patients, good results in 9 patients and fair in 3 patients. (Table 3).

	Pre (mean \pm SD)	Post (mean \pm SD)	Last (mean \pm SD)	Loss of correction	Pre vs. post	Pre vs. Last
Kyphosis angle (degree)	$22.73^\circ \pm 4.85$	$4.53^\circ \pm 2.35$	$5.75^\circ \pm 1.66$	$1.4^\circ \pm .69$	< 0.001*	< 0.001*
Intervertebral height (cm)	5.4 ± 0.75	6.0 ± 0.66	5.6 ± 0.63	0.4 ± 0.95 (6.6%)		
Pain (VAS)	8.29 ± 1.1	4.23 ± 0.52	2.03 ± 0.64		< 0.001*	< 0.001*
ASIA (No)						0.005**
C	8		0			
D	10		5			
E	20		33			

Table 4: Local kyphosis angle, intervertebral height, ASIA grade and VAS for pain.

No perioperative mortality cases. Superficial wound infection in three patient and resolved by repeated dressings. One deep wound infection patient in 65 years old required secondary debridement 2 weeks after the index operation.

Discussion

Surgical management of pyogenic spondylodiscitis aims to eradicate of infection, achieving solid bony fusion with proper good spinal alignment and improving patients' quality of life. Surgical treatment consists of radical debridement of the anterior infected necrotic tissues, reconstruction of the anterior column and proper spine stabilization. Standalone anterior reconstruction using tricortical iliac bone graft or cage has high risk of cage dislodgement, graft collapse, increase local angular kyphosis, long term of brace immobilization lead to difficult rehabilitation in such high-risk patients [15,16]. Anterior approach related complication like vascular or visceral injury is not uncommon. Posterior pedicle screw fixation prevent graft collapse, maintain kyphosis correction, allows earlier reintegration in the community [17,18]. Titanium instrumentation can safely be used in pyogenic spondylodiscitis [12,19]. Vertebral body are highly vascular so reconstruction of the anterior defect in spinal infection can be successfully achieved by tricortical iliac bone graft [12], allograft [19], titanium mesh cage [20-23] and PEEK cages [23,24] or even with spinal shortening [25]. Posterior only approach in treating spinal infection has several advantages but spread of infection to the dural sac is still a risk especially if we will sacrifice nerve root while inserting cage anteriorly from posterior approach, manipulation of the cord at the dorsal spine is critical, dislodgement of the cage or graft through the posterior annular defect may be a devastating complication.

In this study we propose the transpedicular posterior approach can avoid these complication as we preserve the integrity of posterior annulus and posterior longitudinal ligament. We are safe as we have transpedicular corridor to the anterior column debridement and reconstruction which is away from the neural structures. Impacted morselized graft and posterior screws can restore anterior and posterior columns integrity. Patients had significant immediate improvement of their clinical and radiological scores with less analgesia.

There was no perioperative mortality or devastating complications. 5 patients required postoperative I.C.U admission for ob-

servation over night for medical non-surgical causes. Neurological improvement of patients was anticipated, and no neurological complication was anticipated from the surgical procedure either immediately or at last follow up. The cost was also decreased due to no implants needed to reconstruct anterior column and the short hospital stay in uneventful technique.

Impaction bone graft has been successfully used in spine surgery with good outcomes [26]. Some surgeons used bone graft in pyogenic spinal infection using either a structural tricortical iliac bone graft [8,12,15,27] or allograft [8,19]. 27 patients of lumbar spondylitis surgically treated by the transforaminal lumbar interbody fusion using the titanium cage in 17 patients and iliac bone graft in 10 patients [22]. There was no difference in the results between both the graft and the cage. Studies have shown that local bone graft has comparable fusion rates to iliac crest graft [27].

No data to the best of our knowledge highlighting the efficacy of transpedicular morselized locally harvested impacted bone graft alone or mixed with iliac crest graft and vancomycin antibiotics powder in treating pyogenic spondylodiscitis. However, by approaching the infected disc space through the vertebral end plates, may promote invasion and absorption of the infection process by vascular granulation tissue from the vertebral body through the subchondral bone. This concept is also echoed in Nagata's approach in which the end plate of the vertebral body is removed using a motor-driven shaver [29]. In this study, the locally posteriorly harvested bone graft was used from posterior elements, with or without additional iliac bone graft depending on the size of the anterior defect. The Clinical, radiological, and functional results were satisfactory to the patient and the surgeon.

This surgical technique allows safer insertion of the morselized bone graft in the anterior void. The technique avoids retraction and manipulation of the neural elements. It avoids excessive excision of the posterior elements as in cases of inserting a structural graft or cage from posterior approach. This allows early recovery of the patients. Moreover, this method allows more bone graft to be impacted and further graft reinserted and adjusted after correction of the local segmental kyphosis with opening of the anterior disc space by the posterior construct. Also using the local morselized bone graft decrease the required big amount of iliac crest bone graft alone. Theoretically morselized bone graft increases the graft surface area available for fusion.

Ha KY, *et al.* [13] reported a reduction in the intervertebral height after using anterior tricortical iliac bone graft with and without posterior fixation due to subsidence. Factors contributing to Subsidence included endplate destruction, remodelling, and softening of the bone graft, the telescoping collapse of the structural graft into the cancellous vertebral body. In this study the average height loss was 0.5 cm. Subsidence does not occur with the morselized bone graft because the elasticity and mechanical strength are near to that of the cancellous vertebral body. Plus, the presence of a stable posterior fixation.

This biological safe technique is avoiding the complications of cage as retropulsion, migration or subsidence [30] and the lower cost especially in price sensitive markets [26]. The mechanical strength of the morselized graft is increased by impaction and slight shortening. This increases the load sharing properties of the graft during the early period of fusion and leads to close contact between the graft and the bone bed [26,31]. Posterior fixation is the prime stabilizing factor, protecting the graft collapse and absorption during the early stage of postoperative period. Comparative studies of anterior graft only and additional posterior instrumentation showed that is much better. ⁽¹⁵⁾ This study supported that no major collapse or graft absorption, that is proved by minor changes in the intervertebral heights and local kyphotic Cobb angle.

Some surgeons reported 1° loss in the local kyphosis angle after combined anterior tricortical iliac graft and posterior instrumentation [17]. Korovessis P, *et al.* [30] in a systematic review of literature over a decade about titanium cage in spinal infection reported local kyphosis angle loss of 3° (range, 0.6-10°). The high and wide range of loss in cases of titanium cages among studies may be attributed to the different amount of endplate and vertebral body destruction and subsidence. The average local kyphosis angle loss in cases of posterior only surgery was 1.8° by Lee and Suh [10] using debridement, tricortical iliac graft and posterior instrumentation, 4° by Gorensek, *et al.* [21] using posterior titanium and PEEK cages and 3° by Lin, *et al.* [18] In this study, the average loss using the impacted graft was 1.4° which is comparable to or slightly lower than the loss in posterior only approach using tricortical iliac graft by Lee and Suh [10] and slightly larger than the combined anterior grafting and posterior instrumentation by Sundararaji, *et al.* [22] but without clinical neurological or functional effects.

In spinal infection, the biological environment for bony fusion is adequate; the bony endplate is usually destructed exposing the highly vascular cancellous vertebral body bone and the blood supply is increased due to the hyperaemia of inflammation. Debridement improves the vascularity by adequate removal of the disc material and the necrotic bone. This puts the morselized graft in a highly vascular bed and within the confines of the vertebral bodies like a contained defect on the compression side of the spine.

As antibiotic treatment is the gold standard of treatment of spinal infection, surgical treatment should be followed by a sufficient period of I.V antibiotics of at least four weeks to be followed by oral antibiotics till normalization of the infection profile to have a good result.

Spinal shortening of 10 mm may decrease anterior defect size and shown to increase the stability of the construct [31,32]. Maintain the posterior facets and using transpedicular corridor protect cord from shortening and dura from buckling.

The limitation of this study is absence of a control group.

Conclusion

Transpedicular posterior impaction of the morselized bone graft mixed with antibiotic powder in Thoracolumbar pyogenic spondylodiscitis is safe and cost-effective technique with good clinical, radiological, and functional outcomes.

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