■ SPINE

A comparison of the long-term results of anterior lumbar interbody fusion and total disc arthroplasty: a prospective randomized controlled trial with a mean follow-up of 14 years

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Aims

This prospective randomized study compares the clinical and radiological long-term outcomes of single-level anterior lumbar interbody fusion (ALIF) and total disc arthroplasty (TDA).

Methods

Patients with symptomatic single-level degenerative disc disease (DDD) at L4/5 or L5/S1 were randomly assigned to groups ALIF or TDA. Clinical evaluations using the Oswestry Disability Index (ODI) and visual analogue scale (VAS) for pain were conducted preoperatively, at three, 12, and 24 months, and after a mean follow-up of 14 years (12.2 to 15.9). Radiological assessments included radiographs in two planes and flexion-extension views. Additionally, CT was performed in the ALIF group to evaluate fusion after 24 months. Complications and patient satisfaction were recorded. Outcomes were analyzed for the entire cohort and by spinal segment.

Results

Of the 120 patients included (60 per group), 28 were lost to follow-up, including three excluded because of revision surgery. In the remaining patients, significant improvements in ODI and VAS were seen over time (all $p < 0.001$). Clinical scores had declined slightly by final follow-up but remained better than the preoperative levels. No significant overall differences were found between ALIF and TDA. However, subgroup analysis revealed that ALIF outperformed TDA at L5/S1 (ODI posthoc test at final follow-up $p = 0.005$): outcomes were comparable at L4/5.

Conclusion

Both ALIF and TDA are safe and effective methods of treating single-level DDD. ALIF is preferable at L5/S1 due to biomechanical factors, such as variability in the centre of rotation and sagittal profile types, which have a negative impact on the outcomes of TDA at this level. Conversely, at L4/5, both procedures give comparable results. These findings emphasize the importance of considering segment-specific anatomical and biomechanical factors in surgical decision-making for DDD.

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Introduction

Globally, low back pain (LBP) accounted for 83.0 million disability-adjusted life-years in 2010.[1] Total disc arthroplasty (TDA) was expected to prove to be an effective treatment for degenerative disc disease (DDD)-related LBP and to significantly reduce the need for spinal fusion. However, this has not been the case. Despite critical views about its indications,[2] segmental fusions remain popular, whereas lumbar TDA is rarely used.

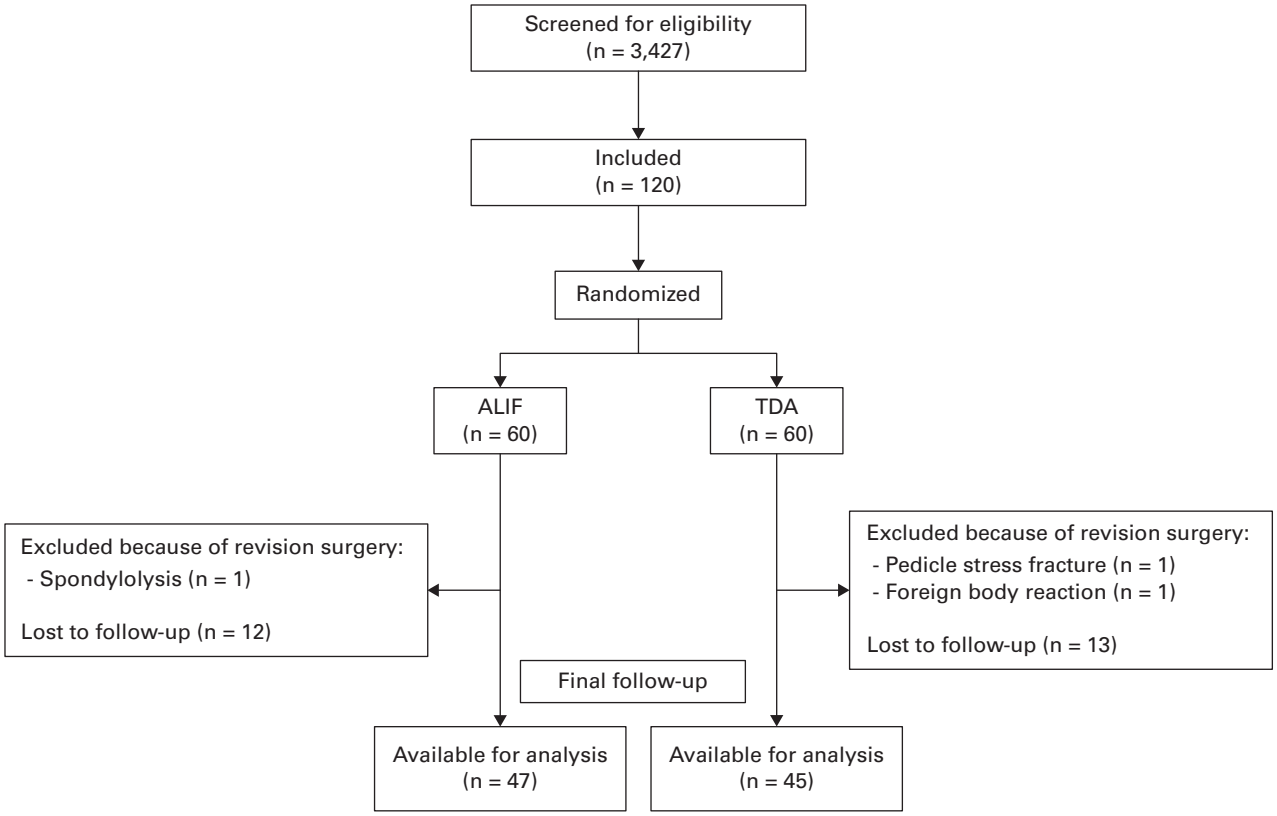

Fig. 1

The figure shows the patient flowchart from screening to final analysis of the present study. ALIF anterior lumbar interbody fusion; TDA, total disc arthroplasty.

Table I. Fusion criteria according to CT and radiograph.

Radiological criteria for fusion evaluation of both groups at 24 months and final follow-up*	
1	Motion < 3° in extension-flexion radiographs
2	Lack of dark halo around implant material
3	Lack of visible fractures of the device, graft, or vertebrae
4	Lack of substantial sclerotic changes in the recipient bone bed or the graft
5	Visible bridging bone around the implant in plain AP and lateral radiographs
CT criteria for fusion evaluation of the ALIF group at 24 months*	
1	Lack of any lucency at the implant material margins
2	Lack of any visible fracture of the device, graft, or vertebrae
3	Lack of any cystic changes within the endplates adjacent to the implant
4	Lack of any linear defects (fracture) through intervertebral new bone within or adjacent to the implants parallel to the endplates
5	Lack of high subsidence level of the cages or dislocation
6	A bridging bone in-/external to the implant

*All criteria had to be fulfilled to be judged as fused.
ALIF, anterior lumbar interbody fusion; AP, anteroposterior.

Nevertheless, some reports on 'artificial disc arthroplasty' have reported notably favourable long-term outcomes.[3-6] Registry studies on TDA have also provided convincing evidence of its efficacy.[7] Over time, there has been a noticeable reduction in the indications for TDA.[8-10] Finally, some authors even warned against the implantation of a disc prosthesis.[11]

TDA as been shown to perform better two years after surgery than a standalone anterior lumbar interbody fusion (ALIF).[12,13] However, standalone cages without additional stabilization are limited by their biomechanical properties, as demonstrated by insufficient primary stability or subsidence.[14-16] Therefore, the positive effects of TDA may have been overestimated in these

Table II. Patient characteristics and perioperative data.

Variable	Overall	ALIF	TDA	p-value
Patients, n				
Inclusion	120	60	60	
Final follow-up	92	47	45	
Sex, F:M				
Inclusion	67:53	36:24	31:29	0.358*
Final follow-up	55:37	31:16	24:21	0.217*
Mean age at surgery, yrs (range)	44.1 (31 to 65)	45.3 (31 to 65)	42.8 (32 to 61)	0.726†
Segment distribution at inclusion, n				0.466*
L4/5	43	20	23	
L5/S1	77	40	37	
Segment distribution at final follow-up, n				0.555*
L4/5	32	15	17	
L5/S1	60	32	28	
Mean surgical time, mins (range)	99.9 (60 to 205)	95.6 (60 to 205)	104.3 (90 to 190)	0.036†
Mean blood loss, ml (range)	82.9 (20 to 600)	90.3 (20 to 600)	75.1 (20 to 490)	0.648†

*Chi-squared test.
†Two-sided *t*-test.
ALIF, anterior lumbar interbody fusion; TDA, total disc arthroplasty.

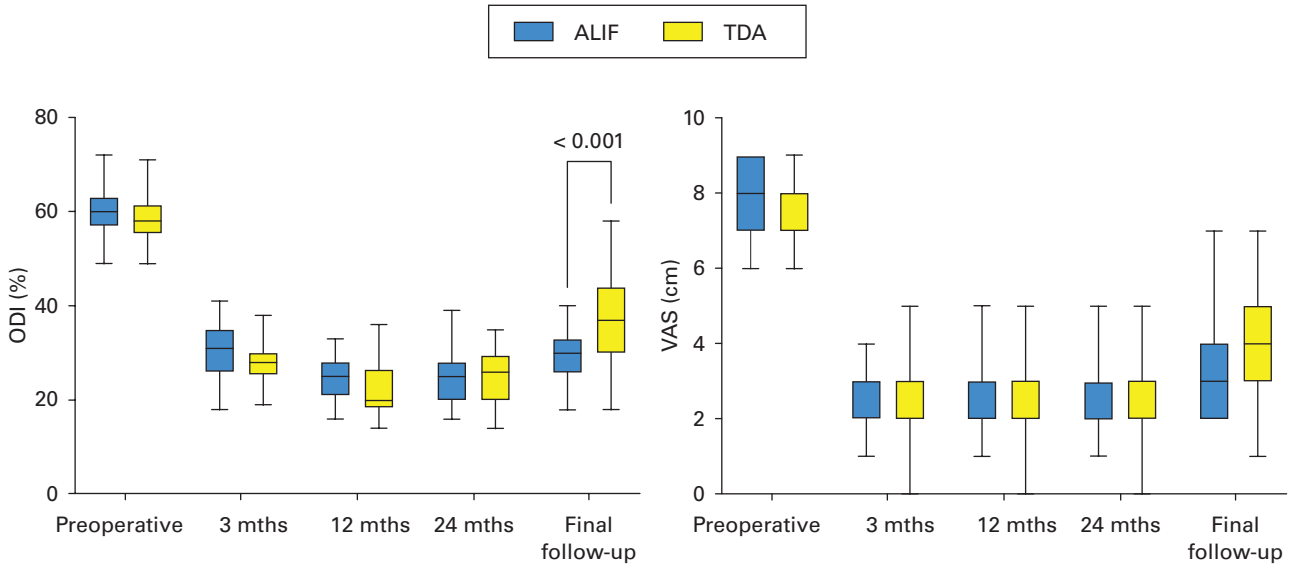

Fig. 2

Outcome of the a) Oswestry Disability Index (ODI) and b) visual analogue scale (VAS) for pain over time between the groups. The p-value at final follow-up (ODI) results from post-hoc testings. Whiskers represent minimum to maximum. ALIF, anterior lumbar interbody fusion; TDA, total disc arthroplasty.

studies.[17] Furthermore, the additional use of a posterior (i.e. dorsal) surgical approach for transpedicular fixation negatively affects the clinical and radiological outcomes after fusion.[18-20] Consequently, randomized controlled trials (RCTs) must also be critically evaluated.

The aim of the present prospective study was to compare the outcomes of single-level lumbar TDA with additionally anteriorly stabilized ALIF in the long term. The hypothesis was that TDA would prove to be better. As recent publications suggest that the success of TDA and fusion is influenced by the treated segment level,[9,21] a segment-by-segment comparison was also undertaken.

Methods

This prospective randomized long-term study was carried out at a single university orthopaedic department (Center for Musculoskeletal Surgery, Charité–Universitaetsmedizin Berlin, Berlin, Germany) between January 2008 and December 2023. The study was carried out in accordance with the World Medical Association Declaration of Helsinki.[22] All patients had to sign an informed patient consent before inclusion. The study was ethically approved by the Institutional Review Board under rule no. EA1/055/08.

Patients. Patients with symptomatic DDD at L4/5 or L5/S1 (L6-S1 with six free lumbar vertebrae) with Modic stage ≥

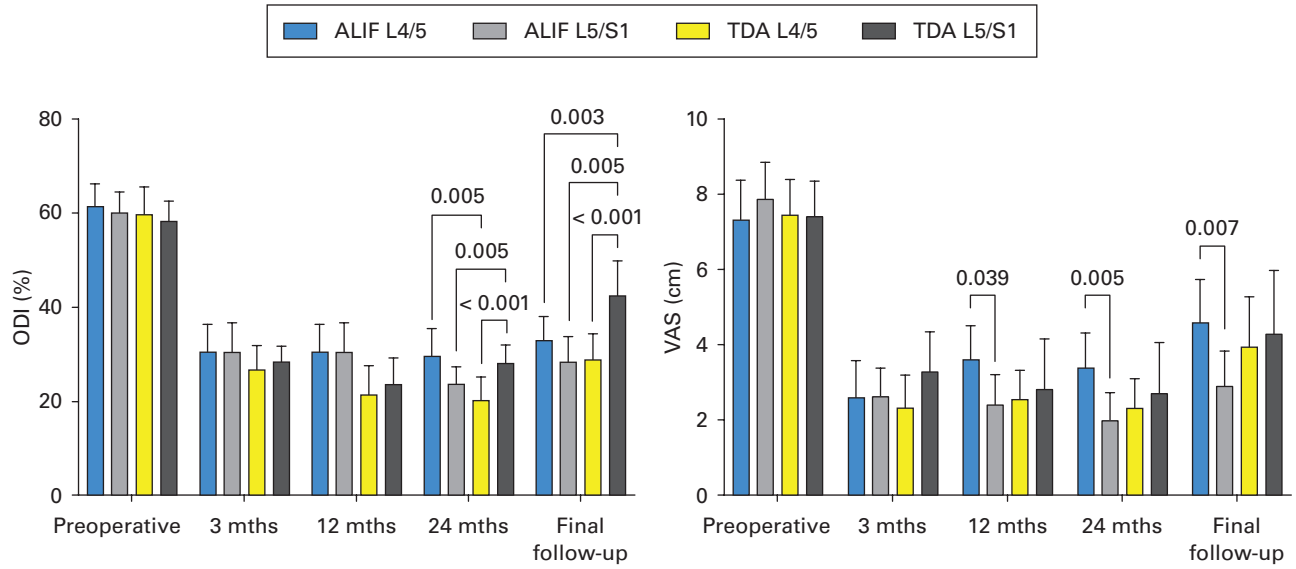

Fig. 3

Segment-related (L4/5 or L5/S1) outcome of the a) Oswestry Disability Index (ODI) and b) visual analogue scale (VAS) for pain over time between the groups. Thus, over time up until final follow-up, the anterior lumbar interbody fusion (ALIF) group shows less functional impairment (ODI) than total disc arthroplasty (TDA), treatment of L4/5 less than L5/S1, whereas at L5/S1 ALIF performs best, followed by TDA L4/5, ALIF L4/5, and TDA L5/S1. Looking at the development of pain (VAS) until final follow-up, pain was stronger when L4/5 was treated and when TDA was performed leading to the best results for ALIF L5/S1, followed by TDA L4/5, TDR L5/S1, and ALIF L4/5. p-values result from post-hoc testings. Whiskers represent single SD.

Table III. Willingness to undergo the procedure again under same conditions at final follow-up.

Segment	Overall	ALIF	TDA	p-value*
L4/5	27/32	13/15	14/17	
L5/S1	54/60	31/32	23/28	
Overall	81/92	44/47	37/45	0.256

*Chi-squared test.
ALIF, anterior lumbar interbody fusion; TDA, total disc arthroplasty.

Table IV. Patient satisfaction at final follow-up.

Satisfaction	Overall	ALIF	TDA	p-value*
L4/5				0.355
Excellent	3	0	3	
Good	20	10	10	
Fair	9	5	4	
Poor	0	0	0	
Overall	32	15	17	
L5/S1				0.045
Excellent	11	8	3	
Good	28	17	11	
Fair	17	7	10	
Poor	4	0	4	
Overall	60	32	28	
Overall				0.176
Excellent	14	8	6	
Good	48	27	21	
Fair	26	12	14	
Poor	4	0	4	
Overall	92	47	45	

*Chi-squared test.
ALIF, anterior lumbar interbody fusion; TDA, total disc arthroplasty.

2 changes,[23] a residual disc height of > 7 mm and/or a neuroforaminal stenosis (detectable on MRI) were enrolled in the study. All patients had severe LBP, which was often combined with radicular leg pain, and had undergone unsuccessful conservative treatment for at least six months prior to surgery. Preoperatively, all patients had standardized erect lumbar spine radiographs in anteroposterior (AP) and lateral views, and an MRI of the lumbar spine.

Patients were excluded from the study if they had degeneration of adjacent segments on MRI. Additionally, individuals who had significant fatty degeneration of the paravertebral posterior muscles exceeding 50%, as indicated on MRI were also excluded.[24]

Further exclusion criteria were as follows: additional degenerative findings; painful facet joint degeneration (Fujiwara grade > 2;[25] infiltration test with a local anaesthetic drug); spinal deformities or destructive processes; spondylolisthesis; claudication from a spinal stenosis; previous operations on the lumbar spine; patients under long-term medication regimens involving corticosteroids or non-steroidal anti-inflammatory drugs; patients with chronic pain ≥ stage II;[26] patients with osteoporosis, kidney and liver disease, malignant tumours, or a BMI of > 30 kg/m²; pregnancy; and chronic nicotine, alcohol, or drug abuse.

Using Randlist software (DataInf, Germany), patients were randomly assigned to groups ALIF or TDA (Figure 1). Randomization was unblinded to the surgeon two days before surgery. An a priori power analysis was conducted to estimate

Table V. Radiological outcomes in patients available at final follow-up.

Variable	Overall	ALIF	TDA	p-value*
Mean PI, ° (SD)				
Overall	48.8 (6.8)	47.8 (6.8)	49.9 (6.7)	0.156
L5/S1	48.9 (6.7)	47.8 (6.1)	50.2 (7.2)	0.195
L4/5	48.7 (7.2)	47.8 (8.3)	49.4 (6.2)	0.524
Mean preoperative pelvic tilt, ° (SD)				
Overall	20.8 (5)	22.3 (4.1)	19.2 (5.5)	0.003
L5/S1	21.8 (4.4)	23.1 (3.2)	20.3 (5.2)	0.015
L4/5	18.9 (5.6)	20.5 (5.3)	17.4 (5.5)	0.109
Mean delta pelvic tilt, ° (SD)				
Overall	-3.7 (4)	-4.4 (4.2)	-2.9 (3.6)	0.070
L5/S1	-3.7 (4.4)	-4.3 (4.5)	-3 (4.4)	0.248
L4/5	-3.6 (3.1)	-4.6 (3.9)	-2.8 (1.8)	0.109
Mean preoperative segmental lordosis, ° (SD)				
Overall	18 (6.5)	17.4 (5.7)	18.6 (7.2)	0.397
L5/S1	17.6 (5.3)	17.4 (4.7)	17.8 (6.1)	0.739
L4/5	18.8 (8.2)	17.6 (7.7)	19.8 (8.8)	0.451
Mean delta segmental lordosis, ° (SD)				
Overall	3.5 (5.3)	3.8 (4.1)	3.2 (6.4)	0.635
L5/S1	4 (5.5)	4.2 (3.7)	3.7 (7.2)	0.768
L4/5	2.6 (4.9)	2.9 (5)	2.4 (4.9)	0.790
Mean preoperative LL, ° (SD)				
Overall	43.9 (11.7)	41.7 (10.3)	46.2 (12.7)	0.066
L5/S1	43.2 (13.3)	42.1 (8.3)	44.5 (12.1)	0.361
L4/5	45.1 (14.1)	40.8 (13.9)	48.8 (13.5)	0.109
Mean preoperative LL-PI, ° (SD)				
Overall	-5 (13.5)	-6.1 (12.8)	-3.7 (14.1)	0.391
L5/S1	-5.7 (11.6)	-5.7 (9.2)	-5.7 (14)	0.981
L4/5	-3.6 (16.5)	-7 (18.7)	-0.5 (14.3)	0.275
Mean delta LL (= delta LL-PI), ° (SD)				
Overall	-0.2 (6.9)	-0.1 (5.9)	-0.1 (7.9)	0.994
L5/S1	-0.1 (7.5)	-0.2 (6.5)	-0.5 (8.6)	0.720
L4/5	-0.2 (5.7)	-1 (4.3)	0.4 (6.8)	0.497

*Two-sided unpaired *t*-test.
ALIF, anterior lumbar interbody fusion; LL, lumbar lordosis; PI, pelvic incidence; TDA, total disc arthroplasty.

the necessary group size for measuring superiority based on the minimal clinically important difference of the primary endpoint (Oswestry Disabilty Index (ODI);[27,28] 15%)[29] between the groups ($\beta = 0.20$, $\alpha = 0.05$). Calculating a dropout of about 30%, the group size was set at 60.

Surgical technique. The surgery in both groups was undertaken by the same senior surgeon (MP) through a pararectal retroperitoneal approach, as described previously.[30] In the ALIF group, a polyetheretherketone cage (SynFix LR; Depuy Synthes, Switzerland) with an integrated titanium plate filled with freeze-dried allogenic cancellous bone was inserted in the intervertebral space and anchored with four diverging 25-mm-angle-stable locking screws into the adjacent vertebral endplates.[31,32] In group TDA, a Maverick disc prosthesis (A-Mav; Medtronic, USA) was implanted anteriorly. Each patient was mobilized without an orthosis and received physiotherapy from the first postoperative day.

Data collection. All patients underwent clinical and radiological examinations preoperatively, at three, 12, and 24 months postoperatively, and at a mean follow-up of 14 years (12.2 to 15.9).

During the perioperative period, the mean duration of surgery and intraoperative blood loss, as well as the length of the patients' hospital stay, were recorded. Implant and non-implant-related complications, ascertained both during and after the operation, were monitored until final follow-up.

The ODI was used to assess subjective functional impairment. In addition, pain quantity was estimated using a visual analogue scale (VAS), with a scale graduation of 0 to 10 (0, minimal pain and 10, maximal pain).[28] At final follow-up, patients' willingness to undergo the operation again under the same conditions and satisfaction with the treatment were recorded with four levels of categorization: excellent, good, fair, and poor.

Radiological analysis was based on pre- and postoperative standardized erect lumbosacral spine radiographs in AP and lateral views, and assessed pelvic incidence (PI), lumbar lordosis (LL), segmental lordosis, pelvic tilt (PT), and LL-PI mismatch. Delta values were calculated between preoperative status and final follow-up. Furthermore, flexion-extension radiographs were routinely carried out after 24 months and at final follow-up to assess segmental fusion (Table I). Routine CT was undertaken 24 months postoperatively to further investigate

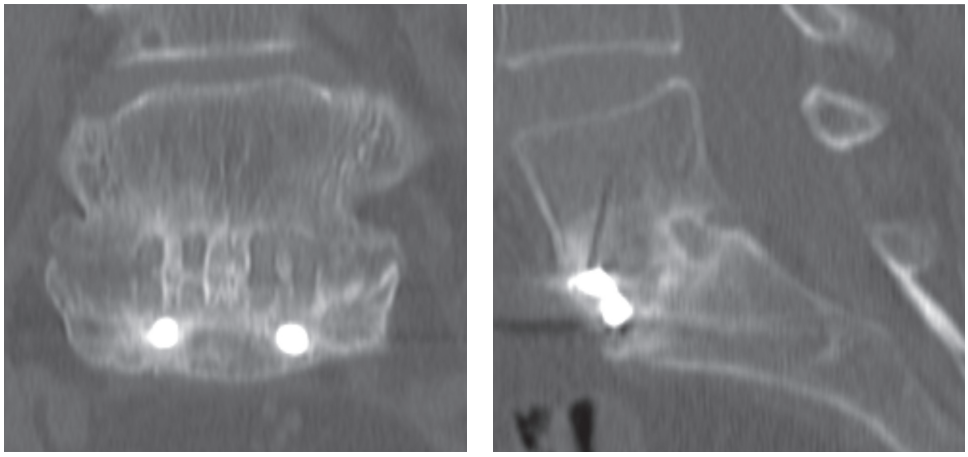

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Fig. 4

a) Coronal and b) sagittal CT reconstructions of a 53-year-old female patient with successful fusion after standalone anterior lumbar interbody fusion L5/S1 at 24 months postoperatively.

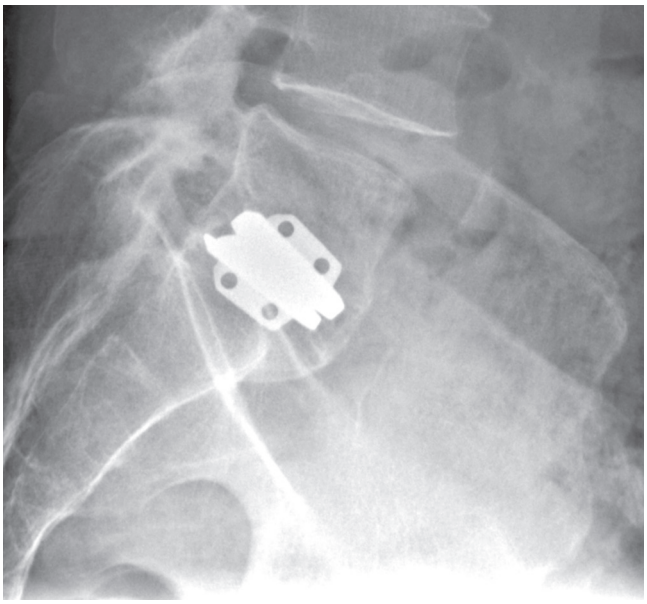

Fig. 5

Lateral radiograph of a 69-year-old male patient with unintended fusion of a patient who received total disc arthroplasty L5/S1 at final follow-up. Bony bridges are visible anterior and posterior to the implant, while the prosthesis shows subsidence into the inferior endplate of L5 posteriorly.

fusion of the instrumented segment in the ALIF group.[31] Additionally, qualitative radiological evaluation of fusion in both groups was in accordance with recently published criteria for vertebral body fusion using interbody implants at 24 months and at final follow-up.[31]

The radiographs and CT reconstructions were evaluated independently and blinded to the patient's identity by both a radiologist specializing in spinal imaging (see Acknowledgements) and an orthopaedic surgeon (JF). Mean values of both were used for comparison between the groups. A second independent orthopaedic surgeon (PS) was asked to adjudicate conflicting fusion findings. Additionally, adjacent segments were evaluated for progression of degeneration: implant-associated complications were recorded at follow-up.

Patient characteristics. A total of 120 patients (67 female, 53 male) were enrolled in the study (60 per group) between January 2008 and December 2010. Apart from mean time for surgery, which was significantly shorter ($p = 0.036$) in the ALIF group, no significant differences were found in the patients' characteristics and perioperative data between the two groups (Table II).

A total of 25 patients did not attend any follow-up and were excluded from further statistical analysis (Figure 1). No adverse events were noted in these patients at the time of exclusion. Additionally, three patients were excluded from the study due to revision surgery associated with a change in the procedure.

All patients were able to mobilize without the need for an orthosis on the first day after surgery. The mean inpatient length of stay was seven days (5 to 9) and eight days (5 to 10) in the ALIF and TDA groups, respectively.

Statistical analysis. The data from this study was analyzed using SPSS v. 28 (IBM, USA) and Prism v. 10 (GraphPad Software, USA). Power analysis was performed using NCSS 2004 and PASS 2005 software (USA). Inter-group comparisons of postoperative ODI and VAS were analyzed using a three-way analysis of variance (ANOVA) for repeated measures and post-hoc Bonferroni tests, perioperative data with two-sided unpaired *t*-tests. Within-group analysis of ODI and VAS was performed with two-way ANOVA for repeated measures and post-hoc Bonferroni tests. Using the Kolmogorov-Smirnov test, the normal distribution of the dataset was checked before applying parametric tests. Categorical variables were analyzed using

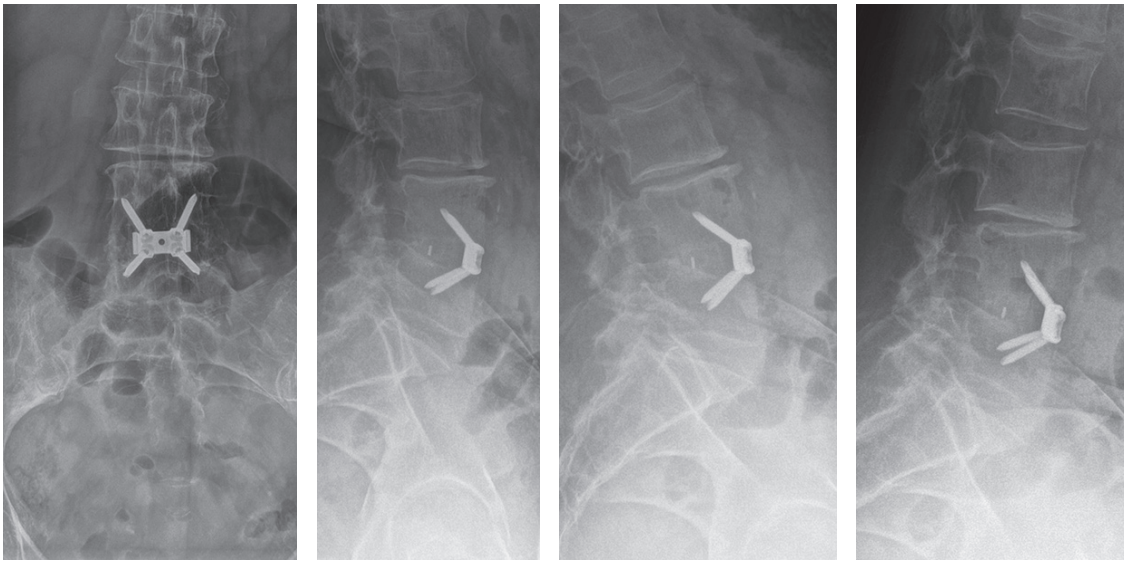

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Fig. 6

The image demonstrates (from left to right) anteroposterior and lateral, as well as extension flexion radiographs of a 52-year-old female patient with superior adjacent segment degeneration at L3/4 after standalone anterior lumbar interbody fusion L4/5 at final follow-up.

the chi-squared test. The interobserver variability was tested using κ-statistics. The significance level for all the statistical tests was $p < 0.05$.

Results

Both groups showed significant improvement in back pain and ODI over the entire period ($p < 0.001$, ANOVA). At each follow-up, clinical scores had improved compared to the preoperative baseline (all $p < 0.001$, ANOVA). In comparison, ODI and VAS showed a significant interaction of treatment with time (ALIF vs TDA: ODI $p < 0.001$, VAS $p = 0.006$, both ANOVA). Post-hoc tests were only significant between the groups for ODI with better results in the ALIF group at final follow-up ($p < 0.001$; Figure 2).

Besides time, three-way ANOVA showed a significant interaction of treatment with time (ALIF/TDR); segment with time (L4/5 /L5/S1); treatment with segment; and treatment with segment with time for ODI (all $p < 0.001$). For VAS, ANOVA showed significant (each $p < 0.001$) effects of time as well as of interaction of segment with time; treatment with segment with time; and treatment with time (here $p = 0.027$; Figure 3).

Patients' willingness to hypothetically undergo the same procedure again did not significantly differ between the groups (Table III). At final follow-up, only at L5/S1 was satisfaction significantly higher in patients who underwent ALIF rather than TDA ($p = 0.045$, chi-squared test; Table IV).

Radiological results. Radiological measurements showed a greater pelvic tilt preoperatively in the ALIF group than in the TDA group (overall $p = 0.003$; subgroup L5/S1 $p = 0.015$, paired *t*-test; Table V). Figures 4 and 5 show CT and radiological images of cases with successful (ALIF) and unsuccessful (TDA) fusion, respectively. At 24 months, radiological images showed fusion in 5/45 patients in the TDA group (8.9%) compared with 42/47 in the ALIF group (89.4%). These rates increased to 9/45 in the TDA group (20.0%) and 45/47 in the ALIF group (95.8%) at final follow-up ($\kappa = 0.858$). At 24 months, CT-based fusion rate (ALIF group only) was 37/47 (78.7%; $\kappa = 0.915$).

However, while the patients who had undergone an ALIF that failed to fuse had poor clinical outcomes, those who had fused did well.

At final follow-up in the ALIF L4/5 subgroup, five patients had adjacent segment degeneration at L5/S1, and one patient at L3/4 (Figure 6). In the ALIF L5/S1 subgroup, L4/5 degeneration was seen in two patients. In one of these patients, recurrent and severe LBP occurred approximately two years after surgery, requiring posterior lumbar interbody fusion of the adjacent segment. In the TDA group, degeneration of the adjacent segment was seen in two cases. However, this remained clinically asymptomatic, as did implant subsidence, which was noted in three cases in each of the two groups.

Complications. In the ALIF group, one patient had a preoperatively unrecognized spondylolysis. Routine radiological follow-up at seven days revealed clinically asymptomatic dislocation of the SynFix LR cage with screw loosening. One patient in the TDA group had a pedicle stress fracture. Another patient in the TDA group also needed surgical revision due to progressive spinal stenosis resulting from a severe foreign body reaction due to implant metal attrition. These three patients were excluded from the study. In the ALIF group, one patient sustained damage to the left common iliac vein during dissection of the L4/5 segment, which was successfully sutured intraoperatively. Postoperative follow-up was uneventful. One patient in the TDA group had a superficial wound dehiscence five days after surgery, necessitating a revision procedure with superficial

wound cleaning and secondary suturing. Additionally, during follow-up, a further patient in the TDA group reported a persistent temperature difference between her feet and intermittent paresthesias in her left leg due to intraoperative damage to the sympathetic nervous system.

Discussion

This study compares the long-term outcome of single-level lumbar TDA and ALIF with additional anterior stabilization. Contrary to expectations, TDA did not give better results, but both techniques provided a satisfactory outcome after 14 years. This RCT is among the first to offer long-term insights into these procedures, suggesting that an anterior approach can be similarly effective as posterior methods in reducing degenerative pain and improving function.[33–35]

Both techniques showed equal efficacy and safety overall. However, segment-specific analysis revealed better results for ALIF at L5/S1, while TDA and ALIF performed similarly at L4/5. Several factors are likely contribute to these differences.

As a transitional segment, L5/S1 is less suited to a mobile implant such as a TDA, which can cause increased motion,[36] progressively increased muscle strain (which carries the risk of muscle fatigue and chronic lumbar pain),[24] and higher stress on facet joints. This leads to a higher rate of degeneration and worse clinical outcome than ALIF.[24,37]

Increased lordosis, exacerbated by TDA due to intervertebral space distraction and ligament resection, imposes additional stress on facets.[38] Outcomes may vary depending on sagittal profile types.[39] Strube et al[40] found significantly worse outcomes in terms of pain and function after TDA for Roussouly sagittal profile types 1 and 4 after a mean follow-up of 39 months and thus considered them a contraindication for TDA.

The inconsistent centre of rotation (COR) at L5/S1[39] is a challenge for prosthetic design and placement. The COR of all types of disc prostheses is predetermined by their design and surgical placement and the chance of reproducing the individually correct COR by the prosthesis is significantly lower at L5/S1 than at L4/5. Anterior displacement of the COR tremendously increases facet joint and facet capsular ligament forces and results in a decreased segmental range of motion (ROM) in a finite element model.[41]

Because the sacrum is fixed to the pelvis, the risk of posterior translation of the L5 vertebra is higher due to unequal resistance during implant insertion at L5/S1 than at L4/5. Rohlmann et al[42] and Strube et al[43] found a negative correlation between clinical parameters (VAS, ODI) and posterior translation of the upper adjacent vertebra. Thus, even a slight posterior translation of 2 mm results in a significant increase in capsular tension and facet joint shear forces, possibly leading to the progression of pre-existing mild facet joint degeneration. Siepe et al[37] had previously reported a higher rate of facet joint degeneration and poor clinical outcomes after TDA at L5/S1 in a clinical study and concluded that this was due to an incompatibility between physiological and prosthetic biomechanics.

Despite concerns about adjacent segment degeneration with ALIF, this was not a significant problem at L5/S1, whereas at L4/5 it caused a radiologically increased rate of adjacent segment degeneration inferiorly.[21] At L4/5, the challenges of TDA, including insufficient translation during flexion and extension, limited shock absorption, and wear debris,[44] may explain its parity with ALIF.

With TDA, degeneration of the adjacent segments was also noted radiologically, although to a lesser extent than with spinal fusion. Interestingly, inadvertent fusion in the TDA group did not correlate with a poor clinical outcome. Whereas with ALIF the segmental lordosis is determined exclusively by the surgeon by the choice of implant, with a functioning TDA the patient can determine this individually. We therefore suspect that ankylosis of TDA happened in a position that was favourable to the individual global and local sagittal balance.

To date, no conclusive advantages have been found among different implant types in terms of factors such as the degree of coupling or the design-based COR of the implant used.[45,46] However, it remains uncertain whether similar results could have been achieved with a non-semiconstrained, uncoupled prosthesis, which is a study limitation. Further limitations of the study results from the loss of power over time because of losses to follow-up, especially in the subgroups of L4/5 and L5/S1, the single-centre design of the study, and the radiological method of fusion assessment which is, in our opinion, rather strict.

In conclusion, while both techniques are viable, ALIF is preferable at L5/S1, and either approach is suitable for L4/5. These findings underscore the importance of tailoring surgical choices to segment-specific anatomical and biomechanical factors.

Take home message

- Over the long term, total disc arthroplasty (TDA) and anterior lumber interbody fusion (ALIF) perform with acceptable clinical and radiological outcomes.
- At L5/S1, ALIF shows better clinical outcomes compared to TDA.

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The present study was ethically approved by Institutional Review Board of the Charité Berlin, Germany under rule number: EA1/055/08. The study was not registered in a study registry because it was initiated 2008. The study was carried out in accordance with the World Medical Association Declaration of Helsinki. Patient consent was obtained from each participant.

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