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# Simultaneous combined anterior and posterior lumbar fusion with femoral cortical allograft

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**Abstract** The radiographic fusion rates, graft behaviour and clinical outcome of 41 patient with simultaneous combined anterior lumbar interbody fusion and posterior arthrodesis with translaminar screws were reviewed independently. In all patients a femoral cortical allograft (FCA) ring filled with autologous iliac crest cancellous bone was used anteriorly to replace the disc and achieve interbody fusion. The follow-up averaged 30.6 months, with a minimum follow-up of 24 months. All patients had disabling low-back pain with different degrees of radiating leg pain and either discogenic pain ($n$ = 24) or a postdiscectomy syndrome ($n$ = 15) respectively postfusion syndrome ($n$ = 2). The overall fusion rate was 95.2% (59 of 62 segments). Time to radiographic fusion averaged 8.7 months (range 2–34 months), and in 66.1% radiographic fusion occurred without significant subsidence. In 18.6% fusion with subsidence resulted from resorption of the FCA and in 15.3% the FCA had protruded into the vertebral body. The posterior intervertebral disc height (PIVDH) increased postoperatively by 2 mm on average. However, loss of PIVDH was the rule, and occurred within the first 12 postoperative months, resulting in a negligible final gain in height of 0.3 mm on average. The segmental lordosis was increased by 3°; however, loss of lordosis during the first 6 postoperative months led to a final gain in lordosis of 1.3° on average. Graft incorporation occurred in 16 of 62 segments (25.8%) and was observed at an average of 21.9 months postoperatively. Subjectively, 82.4% of the patients were satisfied or highly satisfied with the clinical result of the fusion operation. In conclusion, the described technique has proven to be highly effective in achieving a high fusion rate with a good patient outcome.

**Key words** Anterior lumbar interbody fusion · Allograft fusion · Low-back pain · Postdiscectomy syndrome · Discogenic pain

## Introduction

In the treatment of patients with disabling low-back pain, combined anterior and posterior lumbar fusion has become a standard operative procedure. The advantages of this combined approach are a high fusion rate and removal of the disc as a potential pain source [11, 14, 18, 19, 22, 23]. Several techniques have been described using different approaches, implants and grafting materials [2, 4, 10, 20, 25].

Since 1989 the senior author (J.P.O.) has used a femoral cortical allograft (FCA) ring filled with autologous bone (hybrid interbody graft) to replace the disc and to achieve interbody fusion. Advantages of this simultaneous combined anterior and posterior fusion (SCAPF) have been reported to be a rapid and predictable fusion and minimal postoperative height loss [19, 22]. In 1994 Holte et al. published the preliminary radiographic results of 40 patients treated with anterior lumbar fusion using a hybrid interbody graft and different posterior stabilisation devices [16]. The following retrospective study was undertaken to establish the midterm radiographic and clinical results of the SCAPF with the hybrid interbody graft and posterior arthrodesis with translaminar screws (TLS) with special respect to fusion rate and allograft behaviour.

## Materials and methods

All patients treated with a SCAPF with a hybrid interbody graft and posterior arthrodesis with TLS and a minimum radiographic and clinical follow-up of 2 years were included in the study. Forty-one patients (26 women, 15 men) fulfilled these criteria and had an average age at operation of 38.2 ± 9.6 years (standard deviation) with a range of 19.1–58.6 years. Preoperative diagnosis was discogenic pain in 24 patients, a postdiscectomy syndrome in 15 and a postfusion syndrome in 2 patients. All patients had disabling low-back pain with different degrees of radiating leg pain and had been conservatively managed with a rehabilitation programme without success for at least 6 months. In all patients discography was carried out to determine pain source and fusion levels. The preoperative Oswestry Disability Index [7] averaged 40.6 ± 14.9% (range 8–70%).

Twenty-three patients had a single-level fusion, 15 patients a two-level fusion and 3 patients a three-level fusion. In 33 cases the segment L5/S1 was fused, 25 cases L4/5 and in 4 cases L3/4, resulting in a total number of 62 operated segments.

All operation were performed by the same surgeon (J.O.P.). The operative technique has been extensively described by Holte et al. [16]. After anterior fusion the patient is turned and posterior translaminar screw fixation is performed in the corresponding segment without additional posterior bone grafting. In cases of radicular symptoms the corresponding nerve roots are decompressed. The patient is ambulated on the 1st postoperative day and is placed in a removable, moulded plastic jacket until radiographic fusion.

Data on preoperative diagnosis, complications, intraoperative blood loss and operating time were collected. The complications were differentiated into intraoperative, early postoperative, i.e. during hospitalisation, and late postoperative, i.e. post demissionem, complications.

A questionnaire on pain reduction, iliac crest donor site pain and patient's satisfaction as well as return to work was sent to each patient. The degree of improvement of the patient's condition was evaluated by means of a visual analgoue scale ranging from 0 (no improvement) to 10 (totally resolved) and 'worse' in cases of deterioration of the symptoms. Thirty-four patients returned the questionnaire (82.9 return rate) with an average clinical follow-up of 38.4 ± 14.5 months (range 24–71 months).

The patients pre- and postoperative and 3, 6 and 12 months radiographs and later ones (in cases of delayed union), as well as the follow-up radiographs were analysed. The average follow-up of the radiographic analysis was 30.6 ± 10.8 months (range 24–64 months). On the lateral radiographs the posterior intervertebral disc height (PIVDH) was measured to the nearest millimetre selecting the narrowest posterior distance between the endplates according to Holte et al. [16]. To correct the differences in magnification on the different radiographs each PIVDH was multiplied by the magnification ratio. This ratio was calculated by dividing the posterior vertebral body height of L5 on the preoperative lateral radiograph by the posterior vertebral body height of L5 on the corresponding film. To evaluate the anterior intervertebral disc height the segmental lordosis was measured on each lateral radiograph.

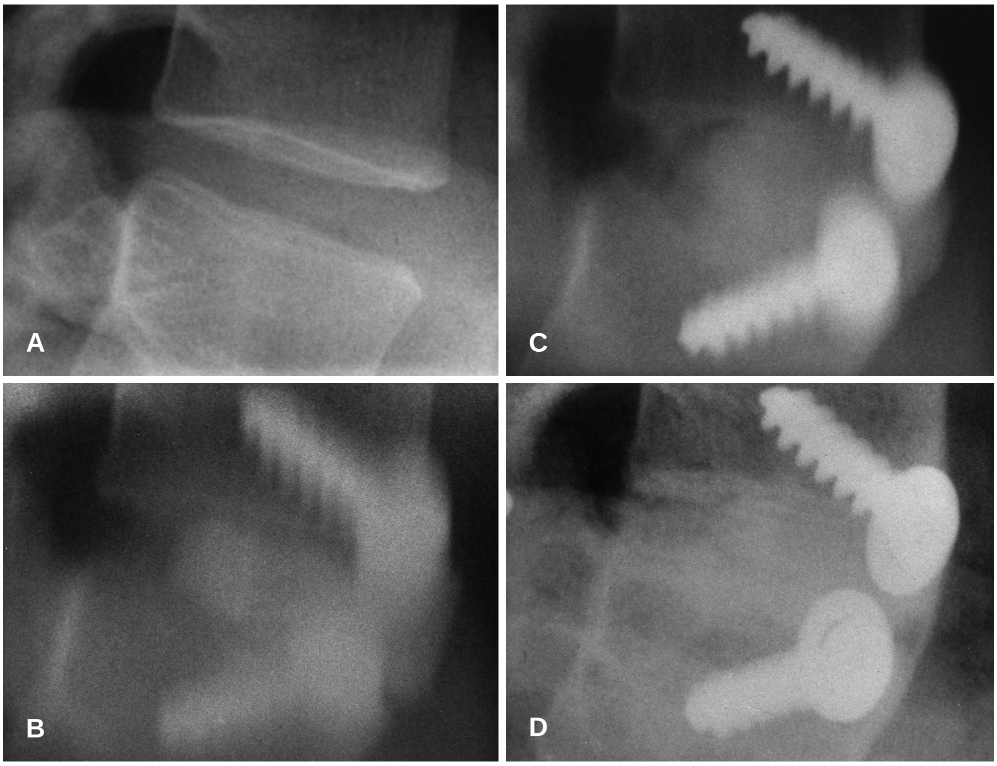


**Fig. 1 A–D** A 34-year-old women with discogenic pain at L4/L5 and simultaneous combined anterior and posterior fusion (SCAPF) with hybrid femoral cortical allograft (FCA). **A** Preoperative lateral radiograph of L4/L5. **B** Lateral tomogram at 3 months postoperatively demonstrates restoration of segmental lordosis. Note the incompletely impacted, anteriorly prominent FCA. **C** At 9 months both interfaces are fused without subsidence. The formerly sharp anterior edges of the FCA are smoothed and, posteriorly to the FCA, new fusion mass is beginning to form spontaneously. **D** Lateral tomogram 24 months postoperatively demonstrates resorption of the unloaded, formerly anteriorly prominent FCA and almost complete spontaneous fusion posteriorly to the FCA, leaving only a lucent line at the upper interface

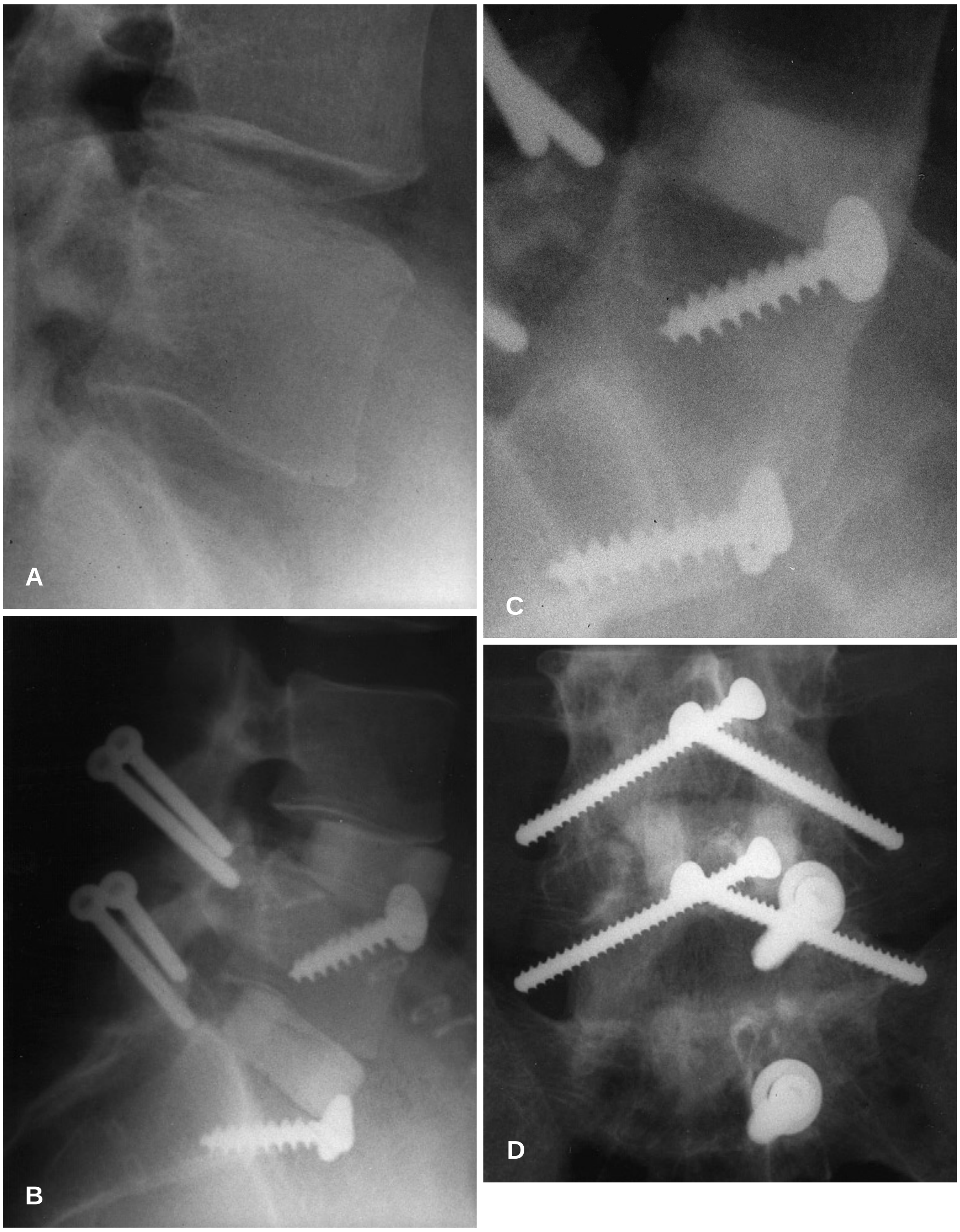


**Fig. 2 A–D** A 39-year-old man with two-level postdiscectomy syndrome and SCAPF L4/L5 and L5/S1 with hybrid FCA: **A** Preoperative lateral radiograph. **B** Postoperative lateral radiograph shows correct placement of the FCA rings with marked increase of the intervertebral disc heights. **C** At 5-years follow-up the lateral radiograph demonstrates complete incorporation at L5/S and spontaneous formation of osseous fusion posteriorly to the FCA rings at both levels, completely bridging the posterior intervertebral disc space. **D** Anteroposterior view at 5 years after surgery

Measurement of the anterior intervertebral disc height appeared too inaccurate due to the washers hiding the landmarks.

Fusion rate was independently evaluated by a consultant orthopaedic radiologist (P.R.) on lateral tomograms, routinely obtained at 3-month intervals until solid fusion. The criteria of radiographic fusion were disappearance of lucent lines and trabecular bony bridging at the allograft-host bone interface [13, 16, 18]. Each graft-host interface was separately evaluated and recorded. Radiographic signs confirming fusion included spontaneous appearance of additional fusion masses posteriorly to the graft and graft incorporation, determined by decrease in density with assimilation of the density of the graft to the host bone (Figs. 1, 2). Graft resorption and mottling were further radiographic findings recorded. Plain lateral radiographs coned on the fusion segment obtained at later follow-ups were assessed with regard to mid- and long-term graft behaviour.

Fusion rates were analysed with regard to level of fusion and number of levels fused. Statistical analysis was carried out applying the chi-square test respectively the Mann-Whitney U-Wilcoxon Rank Sum Test, with a 5% level of significance. Fusion was differentiated into fusion without significant subsidence (change of PIVDH ≤ 2 mm, loss of lordosis ≤ 5°) and fusion with significant subsidence (change of PIVDH > 2 mm, loss of lordosis > 5°).

## Results

The operating time averaged 3.9 ±1.0 h (range 2.5–6.8 h) with an intraoperative blood loss of 604 ± 532 ml (range 100–2500 ml). The complications are listed in Table 1. In

**Table 1** Intra- and postoperative complications

| | |
|---|---|
| Intraoperative complications | Dural tear during posterior decompression (*n* = 1)<br>Peritoneal tear (*n* = 1)<br>Tear of left common iliac vein (*n* = 1)<br>Fracture of FCA (*n* = 1) |
| Early postoperative complications | Nerve root irritation with subsequent revision (*n* = 1)<br>Deep vein thrombosis (*n* = 1) |
| Late postoperative complications | Fracture of FCA 3 months postop (*n* = 1)<br>Incisional abdominal hernia requiring open repair (*n* = 1)<br>Retrograde ejaculation with spontaneous restitutio ad integrum after 6 months (*n* = 1) |

all cases of peritoneal or dural tear the defect was repaired successfully with an uneventful further course. Leakage of the left common iliac vein was immediately repaired with an intraoperative blood loss of 500 ml. The two fractured FCAs fused within 3 respectively 6 months, with some anterior subsidence due to resorption in one case. One patient required posterior exploration and decompression 10 days postoperatively and recovered well with resolution of the radicular symptoms.

## Fusion rates

The overal fusion rates was 95.2% (59 of 62 segments). Time to radiographic fusion averaged 8.7 ± 6.1 months (range 2–34 months). Three segments were radiographically not fused, however; follow-up was between 24 and 30 months in these three patients. A final differentiation between delayed union and pseudarthrosis is therefore not possible. Screw loosening or breakage was not observed in these or other cases.

The time to radiographic fusion averaged 8.9 ± 6.2 months (range 2–30 months) for the single-level fusions and 8.4 ± 1.9 months (range 2–24 months) for two- and three-level fusions. The difference was statistically not significant ($P > 0.05$). Of the three patients with non-fused segments at follow-up, two patients had undergone two-level fusions and one patient a single-level fusion. Time to radiographic fusion averaged 9.9 ± 6.6 months

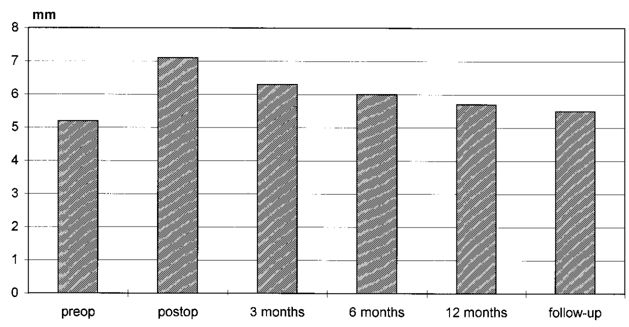


**Fig. 3** Changes of the posterior intervertebral disc height

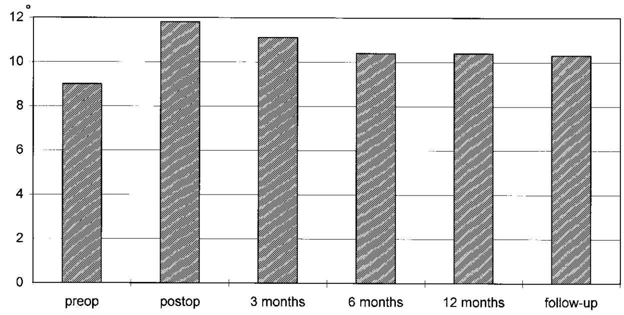


**Fig. 4** Changes of the segmental lordosis

(range 2–34 months) for the segment L4/L5 and 7.9 ± 5.5 months (range 2–30 months) at the L5/S1 level ($P < 0.05$). Between the upper and the lower interfaces of each segment there were no significant differences in fusion rate or fusion time ($P > 0.05$) (Table 2).

Fusion without significant subsidence occurred in 66.1% (39 of 59 segments). In 18.6% (11 segments) fusion with subsidence resulted from resorption of the FCA and in 15.3% (9 segments) the FCA had protruded into the vertebral body. The changes of PIVDH and the loss of lordosis are illustrated in Fig. 3, 4. The preoperative PIVDH averaged 5.2 ± 2.5 mm (range 1–10 mm) and was increased to 7.1 ± 2.7 mm (range 2–12 mm), with a final PIVDH at follow-up of 5.5 ± 2.4 mm (range 1–10 mm). Loss of PIVDH mainly occurred within the first 12 postoperative months, resulting in a final gain in height of 0.3 mm on average. Preoperative segmental lordosis averaged 9.0° ± 4.7° (range –2°–23°) and increased to 11.8° ± 4.4° (range 3°–23°) postoperatively. Segmental lordosis at follow-up was 10.3° ± 4.1° (range 1°–21°) on average, resulting in a final increase of segmental lordosis of 1.3°. The main loss of lordosis occurred within the first 6 postoperative months. The degree of subsidence did not affect the fusion rate ($P > 0.05$).

In 40.3% (25 of 62 segments) osseous fusion proceeded posteriorly to the FCA. These findings were observed 14.7 months postoperatively on average (Fig. 1C, D). Graft incorporation determined by marked decrease of the graft's density occurred in 16 of 62 segments (25.8%)

**Table 2** Number of fused upper and lower interfaces of each segment and corresponding fusion rates (in brackets) at different postoperative intervals

| | L3/4 (4 segments) | | L4/5 (25 segments) | | L5/S1 (33 segments) | |
|---|---|---|---|---|---|---|
| | Upper interface | Lower interface | Upper interface | Lower interface | Upper interface | Lower interface |
| 3 months | 1 (25%) | 2 (50%) | 2 (8%) | 1 (4%) | 5 (15.2%) | 6 (18.2%) |
| 6 months | 2 (50%) | 3 (75%) | 8 (32%) | 12 (48%) | 18 (54.5%) | 20 (60.6%) |
| 12 months | 3 (75%) | 4 (100%) | 16 (64%) | 22 (88%) | 27 (81.8%) | 26 (78.8%) |
| Follow-up | 4 (100%) | 4 (100%) | 23 (92%) | 24 (96%) | 32 (97%) | 33 (100%) |

and was observed at an average of 21.9 months postoperatively (Fig. 2C, D).

### Questionnaire

Concerning donor site morbidity, eight patients (23.5%) reported chronic pain at the iliac crest at follow-up. In the other cases of no current discomfort the time until resolution of symptoms was 5.3 months on average (range 0–18 months). On the visual analogue scale an average score of 6.7 ± 3.2 (range 0–10) was recorded, with two patients reporting a worse condition than before surgery. In the group of discogenic pain the score averaged 7.3 ± 3.1 compared to 5.9 ± 3.1 in the postdiscectomy respectively postfusion syndrome group ($P > 0.05$).

Twenty-eight patients (82.4%) were satisfied or highly satisfied with their clinical outcome, four patients (11.8%) were unsure and two patients (5.9%) were dissatisfied or highly dissatisfied. The rate of subsidence of the FCA did not affect the patient outcome ($P > 0.05$). Of the three patients with non-fused segments at follow-up, one patient was highly satisfied and two patients were dissatisfied with the operative result. In all, 77.4% of the patients returned to work and 67.7% were able to return to the same work as they had been doing before surgery.

## Discussion

The goal of lumbar fusion operations is an early fusion with a high fusion rate and minimal postoperative height loss. The radiographic fusion rate in this study was 95.2%. Fusion rates given in the literature on anterior interbody fusions vary between 19% and 96%, depending on the fixation techniques, the grafting materials and on the methods of fusion evaluation [2, 8, 11, 14, 15, 17, 20, 25]. In previously reported series by the senior author fusion rates ranged between 77.8% for three-level fusions and 97% for one- and two-level fusions [16, 18, 19].

However, accurate radiographic determination of lumbar interbody fusion remains difficult. Stauffer and Coventry [25] considered a pattern of continuous trabeculae traversing the grafted region and the adjacent vertebral bodies as solidly fused. Additionally, bending films excluding motion in the operated segment can help to confirm fusion [8, 19, 20, 25]. Other authors report CT scans to be valuable in the determination of interbody fusion [24, 26]. In this study the criteria of radiographic fusion were disappearance of lucent lines and trabecular bony bridging at the allograft-host interface on lateral tomograms as previously described by the senior author [13, 16, 18]. A study correlating histopathological findings of lumbar interbody fusions with various radiographic methods would be necessary to finally assess the accuracy of the different radiographic criteria.

Hodgson was one of the first authors to describe the simultaneous combined anterior and posterior approach in lumbar fusion operations [22]. Originally, corticocancellous autografts from the iliac crest were used to replace the removed disc and to achieve interbody fusion [19, 22]. Postoperative height loss, pseudarthrosis and donor site morbidity led to the development of various implants such as carbon-fibre cages [1, 26] and titanium rings [20] filled with cancellous bone.

In 1992 O'Brien first reported the use of a femoral cortical allograft (FCA) ring filled with autologous cancellous bone [22]. This technique provided an osteogenic, immunologically equivalent matrix and immediate mechanical stability and was technically easy to modify according to size and shape of the intervertebral space [19]. Encouraged by the good results the senior author started in 1995 to use cancellous allograft to fill the FCA ring to eliminate iliac crest donor site morbidity. Our data revealing a rate of 23.5% of persisting pain at the donor site at an average of 38 months postoperatively and an average time of 5 months until resolution of the symptoms in the remaining patients support the exclusive use of allograft. Preliminary unpublished data on fusion behaviour of exclusive allograft have shown radiographic fusion of all allografts at a follow-up of 9 months. However, longer follow-up is required to finally evaluate the fusion behaviour of exclusive allograft rings. Reports in the literature on the exclusive use of allograft in lumbar fusion operations describe similar fusion rates with allogeneic bone grafts compared to autografts [3, 12, 21].

One of the main goals of lumbar interbody fusion is maintenance of the intervertebral disc height. In this study the PIVDH increased postoperatively by 2 mm on average. However, loss of PIVDH was the rule and occurred within the first 12 postoperative months, resulting in a negligible final gain in height of 0.3 mm on average. Patient outcome and degree of subsidence did not however, correlate significantly. Dennis et al. compared the disc space heights after anterior lumbar interbody fusion and found postoperative height loss in all cases, with return to their original heights or even less [5].

In 34% the postoperative height loss exceeded 2 mm, respectively 5° of segmental lordosis. This height loss resulted either from resorption of the FCA or protrusion of the FCA into the vertebral body. Partial resorption of the FCA mainly occurred within the first 12 months, which may be due to a transient weakening of the graft by vascularisation and remodeling processes. Protrusion of the graft into the vertebral body might have resulted from damage of the endplates during impacting of the relatively hard FCA into the intervertebral space. In other cases the diameter of the FCA was considerably smaller than that of the adjacent vertebral bodies, leading to an erosion of the endplates in the course of axial loading. However, neither graft resorption nor protrusion had any negative effect on the fusion rate. We believe that the preparation of the anterior graft bed is essential. The endplates are mainly preserved in order to maintain maximal compressive resistance; however, partial endplate resection back to punctate bleeding is necessary to achieve sufficient vascularisation of the graft [19]. Furthermore, the FCA should be placed in the centre of the intervertebral space with an appropriate size so that it rests on the cortical rims of the adjacent vertebrae.

After impacting the FCA press-fit into the intervertebral disc space and loading it under axial compression the allograft acts as a scaffold for new bone formation and has an osteoinductive effect. This is shown by a high fusion rate and new bone formation posteriorly to the graft, which was observed in 40% of the operated segments. This may be explained by Wolff's law, which states that the form follows the function. This is demonstrated most impressively in Fig. 1B–D, showing resorption of the anteriorly prominent, and thus unloaded, part of the FCA and simultaneous proceeding of the osseous fusion posteriorly to the FCA due to axial loading.

Concerning the posterior fixation, translaminar screws (TLS) have proven to be ideal in combination with anterior FCA rings. Beside safe and quick insertion, its relatively confined rigidity compared to other fixation systems allows enough axial graft loading, which is essential for osseous union [6]. On the other hand it is rigid enough to allow early ambulation of the patient in a light plastic jacket without risking graft slippage or pseudarthrosis. Holte et al. [16] reported an average time to radiographic fusion of 8 months with TLS compared to 10 months with Steffee VSP fixation and 11 months without any instrumentation.

In summary, simultaneous combined anterior and posterior lumbar fusion (SCAPF) with the use of an FCA ring filled with cancellous bone in combination with posterior translaminar screw fixation has proven to be highly effective, achieving an average fusion rate of 95% with a mean time to radiographic fusion of 8.7 months and a satisfactory clinical outcome.

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