Cage *versus* tricortical graft for cervical interbody fusion

A PROSPECTIVE RANDOMISED STUDY

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We conducted a prospective, randomised study of 42 cervical interbody fusions undertaken with either an autologous tricortical graft or a cage. The factors assessed in the two groups were: (1) time taken to achieve fusion; (2) neck disability index; (3) pain score; (4) interbody height ratio; (5) interbody angle and (6) the influence of smoking on fusion.

No statistical difference was seen in the time taken to achieve fusion, neck disability index, interbody height ratio, or interbody angles. Smoking did not have any effect on the fusion process. The pain score was significantly lower in the tricortical graft group at six months. We conclude that both methods of fusion give similar results, although tricortical graft fusion is cheaper than cage fusion, and is more effective in reducing the pain score.

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The use of cages for stabilisation procedures in the spine takes its origin from the work of Bagby,¹ who developed a stainless-steel basket, which could be packed with cancellous bone in order to stabilise the necks of horses with wobblers syndrome (a form of cervical myelopathy seen in racehorses). Better results were achieved than with the Cloward technique.² The use of cages in the lumbar spine has increased in recent years because of a higher rate of success than with either posterior pedicle-screw instrumentation or isolated bone grafting methods of fusion. The use of cages in the cervical spine, however, has not been shown to

have significant advantages over isolated bone grafting in anterior interbody fusions.³ Anterior cervical decompression involves removal of the soft disc or osteophytic structures from the compressed neural elements. If no formal attempt is made to fuse the operated movement segment, a loss of disc height, increased kyphosis, loss of neural foraminal height and increased pain in the neck and scapular regions can occur.^{4,5} These problems can be reduced if a method of fusion is also used, provided that it incorporates a structural support to replace the disc.⁶ This support can be in the form of allograft or autograft bone, an osteoconductive matrix such as hydroxyapatite with or without bone morphogenetic protein (BMP), a cage, or polymethylmethacrylate (PMMA). Clinical outcomes have been shown to correlate with the fusion process.⁷ The aim of the procedure, in addition to maintaining normal cervical alignment, disc height and neural foraminal height, is to promote a quick and sound intervertebral fusion. PMMA takes an average of two years to acquire bony incorporation.⁸ This period is significantly longer than for other techniques. Allograft also takes longer than autologous bone graft since it is osteoconductive and does not contain the same osteoinductive elements as autologous grafts.⁹ Hydroxyapatite with BMP gave good results in a goat model, with preservation of the architecture of the cervical spine and rapid fusion.¹⁰ Cages combined with cancellous chips, and autologous tricortical graft fusions, also give similar results in terms of time to fusion, success of fusion and alignment of the cervical spine.^{11,12}

The three methods therefore which show promise in terms of reliability and achievement of the surgical goals are autologous structural grafts, cages and osteoconductors in combination with BMP. As the results of these methods are similar, the deciding factors between them would be the complication rate and cost-effectiveness. The cost of cervical spine cages is between £370 for the Ostapek cage (Howmedica, Mahwah, New Jersey) and £456 for the Brantigan cage (Howmedica). Complications, such as displacement of the graft and pain from the donor site, may follow the use of autologous graft.^{13,14} We have therefore, in this study, assessed the need for the use of cages in the cervical spine for interbody fusion. We conducted a prospective, randomised study in order to compare the results of fusion in the cervical spine, using either a cage with autologous graft

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Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1d

Radiographs showing a) poor fusion; no trabeculae cross the disc space, b) average fusion in which a few trabeculae cross the disc space but there is no endplate reaction, c) good fusion in which numerous trabeculae cross the disc space and there is some endplate reaction and d) excellent fusion with trabecular density at the fusion site similar to that of the adjacent vertebral body and an almost complete endplate reaction.

or an isolated, autologous tricortical bone graft harvested from the iliac crest.

Patients and Methods

We undertook anterior interbody fusion of the cervical spine in 42 patients between 30 and 71 years of age. There were 25 men and 17 women. Each patient was assessed

clinically preoperatively and radiologically by plain radiography of the cervical spine and MRI. The preoperative neck disability index (NDI) and pain score were recorded. The latter encompassed five areas; neck pain, arm pain, dysaesthesia, pain in the donor site and pain elsewhere. For each area, a score of 0 to 10 was allowed, using a visual analogue scale, giving a maximum pain score of 50. Brachalgia alone was present in 25 patients, neck pain and

Fig. 2

Diagram showing measurement of the interbody height ratio and interbody angle.

brachialgia in three, myelopathy in eight and a combination of brachialgia and myelopathy in six. The pathology was identified as a soft disc in 20 patients, disc and osteophytes in 12, osteophytes alone in nine, and canal stenosis in one.

We conducted the study prospectively using the following outcome measures: 1) the NDI at six months; 2) pain scores at six months; 3) time taken to achieve a good fusion; 4) the influence of smoking on fusion times; 5) changes in the interbody height ratio; and 6) the interbody angle. We also recorded a summary of the main symptoms and the subjective opinion of the patient at follow-up at six months. The target number of patients to achieve a power of 90% at a 5% significance level, with a standardised difference of 1, is 40 if a Nomogram method is used for the calculation of sample size.

The patients were randomly allocated between either fusion with an Ostapek cage or with a tricortical graft harvested from the iliac crest. The method of randomisation was based upon the last digit of the date of birth. For odd numbers, the patient underwent a cage fusion and for even numbers, a tricortical graft was used.

The same surgeon (AJ) carried out all the operations using halo traction, an anterior approach to the cervical spine, intraoperative identification of the vertebral level and

removal of the disc and osteophytes using an operating microscope and high-speed burrs. For tricortical graft fusions, we used a Smith-Robinson technique.¹⁵ No plates were used to augment any of the fusions. Postoperatively, the patients were immobilised in a cervical orthosis for six weeks.

Follow-up was at six weeks, three and six months and one year. At each visit the patients underwent clinical assessment, a series of radiographs including lateral flexion, neutral and extension views of the cervical spine and measurement of the NDI and pain score. An independent investigator (AS) assessed the radiographs in order to eliminate bias, and to allow interobserver error to be measured. In order to validate the measurements, another investigator (AJ) assessed a random selection of radiographs and we compared the results. The outcome was valid and consistent for both sets of measurements.

Analysis of the radiographs included the grading of fusion, measurement of the interbody height ratio and the interbody angle. The fusion was graded as poor, average, good or excellent. In a poor fusion there were no trabeculae crossing the disc space, there was interbody movement in the flexion-extension arc and there was no endplate reaction (Fig. 1a). In an average fusion there was no interbody movement, a few trabeculae crossing the disc space, but no endplate reaction (Fig. 1b). In a good fusion there was no interbody movement, numerous trabeculae crossing the disc space and some endplate reaction (Fig. 1c). In an excellent fusion there was no movement and the trabeculae crossing the disc space were of the same density as the adjacent bone. The endplate reaction was also complete so that the two vertebral bodies took on the appearance of one elongated vertebral body (Fig. 1d). The interbody height ratio is measured as the total vertical height of the two vertebral bodies which form the movement segment, divided by the anteroposterior (AP) diameter of the upper vertebral body on a lateral radiograph (Fig. 2). This eliminates the magnification variation in the measurements taken from radiographs. The interbody angle is that between the anterior borders of the two vertebral bodies as measured on a lateral radiograph (Fig. 2). A negative value was given to those which were kyphotic and a positive value to those which were lordotic. Measurements were made on the preoperative films and those taken at six weeks, three and six months and one year. We also recorded the patients' smoking status at the time of surgery.

Analysis of the data for each group included the following: 1) comparison of the time taken to achieve a good fusion; 2) the time taken to achieve a good fusion against the smoking status of the patient; 3) the percentage change in interbody height ratio at six months; 4) the change in interbody angle at six months; 5) the NDI score at six months as a percentage of the preoperative NDI score and 6) the pain score at six months as a percentage of the preoperative pain score. The level of significance was set at $p < 0.05$.

Fig. 3

The time taken to achieve a good fusion for both methods.

Fig. 4

The time taken to achieve a good fusion in smokers versus non-smokers.

Results

Time taken to achieve good fusion. The mean time taken to achieve a good fusion in the cage group was 4.7 months (1.5 to 12) and in the tricortical graft group 6.0 months (1.5 to 12). A good fusion was achieved in all patients within 12 months (Fig. 3). There was no significant difference between the two groups (Student's *t*-test, $p > 0.05$).

The mean time taken to achieve fusion for smokers was 5.0 months (1.5 to 12) and for non-smokers 5.6 months (3 to 12) (Fig. 4). The difference between the two groups was not significant ($p > 0.5$).

Change in interbody angle at six months. The mean change in interbody angle in the cage group was -1° (-9 to $+7$) and in the graft group -4° (-13 to $+7$) (Fig. 5). The difference was not significant ($0.1 > p > 0.05$).

Percentage change in the interbody height ratio at six months. The mean percentage change in interbody height ratio was 99% (89 to 114) for the cage group and 95% (79 to 119) for the graft group (Fig. 6). The difference was not significant ($0.5 > p > 0.1$).

Percentage for the preoperative NDI at six months. The mean value for the cage group was 67% (0 to 156) and for the graft group 51% (0 to 275) (Fig. 7). The difference was not significant ($0.5 > p > 0.1$).

Percentage of the preoperative pain score at six months. The mean value was 70% (0 to 264) for the cage group and 35% (0 to 171) for the graft group (Fig. 8). This difference was significant ($0.5 > p > 0.02$). No patient had pain at the donor site at six months. In the graft fusion group, one patient had a significant increase in the pain score postoperatively. The underlying condition in this patient was a mye-

Fig. 5

The change in the interbody angle at six months for both methods.

Fig. 6

The percentage change in interbody height ratio at six months for both methods.

Fig. 7

The percentage change in the preoperative NDI at six months for both methods.

Fig. 8

The percentage change in the preoperative pain scores at six months for both methods.

lopathy with the increase in pain being in the neck and arms. In the cage fusion group, four patients had an increase in the pain score, in one of whom this was significant. This patient also had a myelopathy with the increase in pain being in the neck and arm. In the remaining three patients there was both neck and arm pain preoperatively in one, and arm pain alone preoperatively in two. None had arm pain at six months, although the pain scores had risen because of increased neck pain. The remaining patients, in both groups, whose pain scores had diminished at six months, felt a subjective improvement in their general condition.

Discussion

From our results we can draw the following conclusions. The time taken to achieve cervical interbody fusion does not differ significantly, whether a cage or a simple tricortical graft is used. The graft group took slightly longer to achieve fusion. The time to fusion was not influenced by the patients' smoking status. This observation contradicts earlier studies in which smoking was seen to delay the fusion process.^{16,17} The change in interbody height ratio at six months is not significantly affected by the use of a cage when compared with a graft, although a slightly smaller ratio was observed with a tricortical graft. This may imply some subsidence of the graft. The interbody angle at six months is not significantly different in the two groups. Likewise, the NDI score is similar in both groups at six months. However, the pain score is significantly lower at six months in the graft group. This contradicts what might be expected from the literature since pain from the graft donor site is a major reason for using a cage.

One shortcoming of our study is that a direct comparison of the donor site subcomponent of the overall pain score was not undertaken, although it was not a feature of any of the patients when they were assessed clinically at follow-up. Overall, the results of fusion using a tricortical

graft are equal to, if not slightly superior to those achieved with a cage. The operation is undertaken on patients whose main symptom is of pain and the graft fusion is better than a cage fusion in lowering pain scores. Cage fusion, however, is more expensive because of the cost of the implant. In our unit, approximately 20 cervical interbody fusions are carried out each year. Changing to tricortical graft fusion on the basis of these results would save £8000 per annum.

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