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Bovine Dowels for Anterior Cervical Fusion: Experience in 66 Patients with a Note on Postoperative CT and MRI Appearance

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Summary

Anterior cervical discectomy and vertebral interbody fusion is a widely used technique in the treatment of radicular or cord compression. Instead of using autologous bone removed from the iliac crest, a heterologous bovine dowel was used for fusion. Sixty-six patients presenting with radicular pain or myelopathy were entered into the study retrospectively. Medial herniated, soft or calcified disc, osteophytes with and without herniated disc material, and bony stenosis at one or two levels were shown by CT or MRI studies. Postoperatively, 88% of the patients noted relief of pain and motor improvement. Most of the patients' sensory deficits and myelopathy improved within 6–12 months. No complications occurred and only one re-operation had to be performed at the same level.

In the follow-up period between 1–4 years, no cases of instability after surgery were reported. Operating time and postoperative pain were reduced because bone harvest from the iliac crest was not necessary. In postoperatively performed CT and MRI, the bovine dowel was surrounded by a "halo"-like structure and the specific structure of the bovine implant was still present. No real bony fusion occurred, but clinical stability was equivalent to autologous bone fusion reported in the literature. However, there was no MRI evidence of "living bone tissue" within the bovine dowel. This finding is in contrast to the current belief that the bovine implant is replaced or infiltrated by bony growth.

Keywords: Bovine dowel; cervical discectomy; interbody fusion.

Introduction

For the treatment of cervical disc lesions and cervical spinal stenosis, a number of operative approaches have been described [1–4, 8, 10, 11, 19, 22–24, 26]. Since Cloward in 1958 [7] and Dereymaeker in 1956 [9] described anterior body fusion for the treatment of cervical spine disease, it has become a standard procedure in many centres. The procedure for the anterior cervical discectomy with or without vertebral interbody fusion has been refined many times [2, 4, 5, 13, 14, 16, 18–20]. Many different materials are used for the anterior cervical interbody fusion after discectomy. Initially, bone grafts for the vertebral body fusion were obtained from the Bone Bank. In some centres, the Bone Bank material was replaced by autologous bone removed from the iliac crest. Bone cement, polymethyl-methacrylate (PMMA) and hydroxy apatite ceramic have also been used [5, 12, 20].

We present a retrospective study with 66 patients using a heterologous bovine dowel for anterior body fusion.

Materials and Methods

Between October 1989 and September 1992, 66 patients underwent cervical spinal anterior body fusion with bovine dowel implantation at our institution. Twenty-five patients were female and 41 were male, ranging in age from 26–85 years. The mean age at the time of surgery was 51 years. All patients underwent a thorough neurological examination. A summary of signs and symptoms of the 66 patients is presented in Table 1. The distribution of cervical disease is shown in Table 2.

Diagnostic Studies and Treatment

In all patients, pre-operative cervical spine roentgenograms were obtained, including foraminal and flexion/extension views. In seven patients, only a pre-operative CT scan was used for diagnosis. In these patients the median and paramedian findings in the sagittal and coronal as well as the axial CT views correlated with the neurologic deficit and, therefore, no further imaging studies were necessary. Fifty-nine patients underwent MRI (0,5 T MRT 50-A Toshiba or 1,5 T S15 HQ Philips). All studies were performed using both T1- and T2*-weighted images. Only patients with radiographic findings that correlated with the neurologic deficits were offered surgery. Criteria for anterior interbody fusion included median and paramedian soft or calcified discs, osteophytes

Table 1. *Pre-operative Symptoms of the Patients (n = 66)*

Signs and symptoms	No. of patients	%
Pain		
Total complaint of pain	51	77
One nerve root	25	38
Two or more nerve roots	26	39
Sensory deficit		
Hypaesthesia	47	71
Dysaesthesia	9	14
Motor deficit		
Radicular motor weakness	15	23
Myelopathy	24	36
Abnormal reflexes	30	46

Table 2. *Distribution of Neurological Symptoms and Radiological Signs in CT or MRI (n = 66)*

Cervical level	Neurologic involvement	Radiologic involvement
C 3/4	5 (8%)	10 (15%)
C 5/5	10 (15%)	17 (26%)
C 5/6	38 (58%)	45 (68%)
C 6/7	42 (64%)	37 (56%)
C 7/Th 1	26 (39%)	4 (6%)
2 or more	35 (53%)	35 (53%)

Table 3 a. *Distribution of Cervical Level for Patients Operated on a Single Level (n = 57)*

Operated level	No. of patients	%
C 3/4	7	12
C 4/5	3	5
C 5/6	23	40
C 6/7	22	39
C 7/Th 1	2	4

with or without herniated disc, or stenosis at one or two levels. Both CT and MRI techniques were used to confirm the diagnosis in nine patients.

Thirty-one out of 66 patients showed radiological changes only in one segment. In these 31 patients, single dermatomal distribution of pain was found. Each patient had no more than three segments of clear pathological findings. Spinal stenosis or midline disc herniation did not always give symptoms corresponding to a single level. In cases where more than one level was involved and no clear relationship to the neurologic findings could be found, electromyography (EMG) was used to determine the segment mainly involved in the disease process. Fourteen patients underwent EMG; three of those patients still had ambiguous findings and, therefore, underwent discography to verify the involved segment.

Table 3 b. *Distribution of Cervical Levels for Patients Operated on Two Levels (n = 9)*

Operated levels	No. of patients	%
C 3/4 + C 4/5	1	11
C 4/5 + C 5/6	5	56
C 5/6 + C 6/7	3	33

Table 4. *Clinical Outcome in 66 Cases of Interbody Fusion with Bovine Dowels After a Follow-up of 1–4 Years*

Outcome	Definition	No. of patients	%
Excellent	no residual symptoms	10	15
Good	residual symptoms minor and not increasing	48	73
Fair	improved, but symptoms persistent and incapacitating	6	9
Poor	no improvement or worse		

Three patients underwent a combined anterior cervical interbody fusion and posterior facetectomy. Fifty-seven patients were operated on at one level and nine patients on two levels. Table 3 a and b show the distribution of pathology.

For interbody fusion after cervical microdiscectomy, we used Unilab Surgibone^R, Mississanga, Canada. All dowels were made out of load-bearing cancellous bone. This bone was free of epiphyseal cartilage and cortical bone. Each bone dowel was treated thermochemically to remove free proteins and compression tested for a load of 250 kgs (for reference see also [17]). The sizes 12, 14, and 16 were used based upon the number of levels and the strength of the cervical spine. When surgery was needed on two levels, only the smaller size 12 dowel was used. For single level fusion the largest dowel possible for the vertebral body size was used.

Standard microsurgical techniques were employed in each case. The longitudinal ligament was opened and removed so that direct inspection of the dura was possible. After drilling of the cylindric shaft and placement of the dowel, an AP and lateral roentgenogram was obtained intra-operatively while the patient was still under general anaesthesia. A soft, cervical collar was used postoperatively for the patients' comfort. The collars were usually removed within 12 hours. All patients were ambulating on *postop* day one. The mean stay in the hospital was five days.

Results

Clinical follow-up time was between 1–4 years. Clinical outcome is shown in Table 4. Eighty-eight percent had excellent or good results. In most

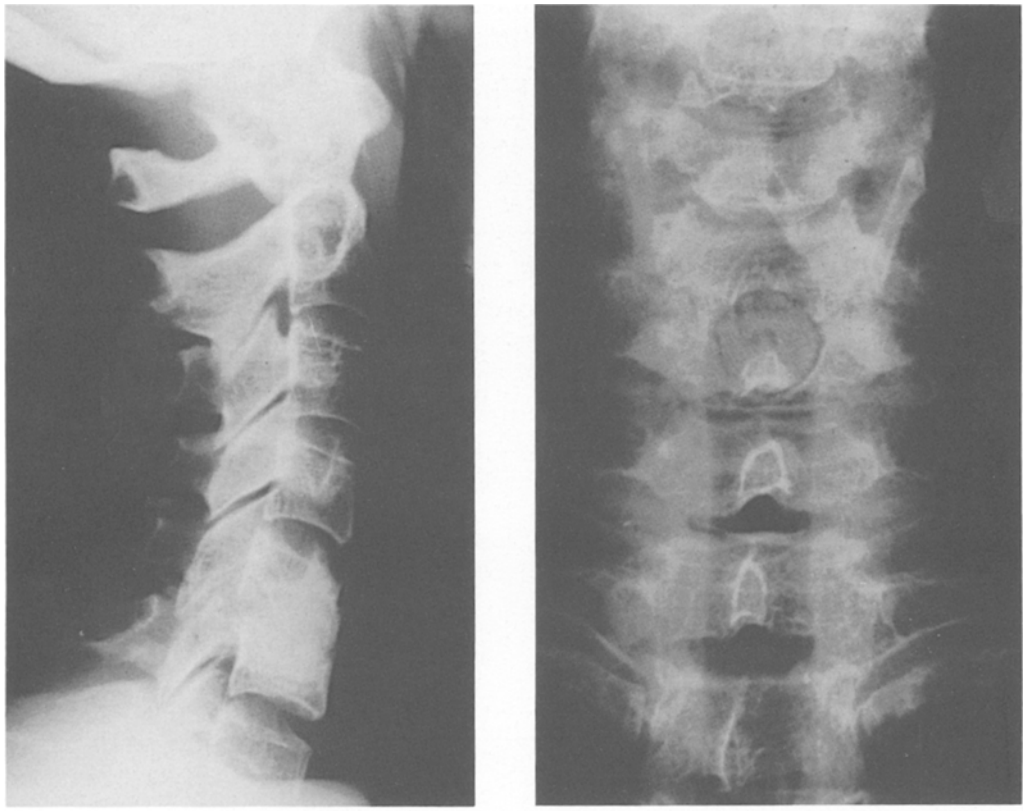


Fig. 1. (a) Roentgengram in lateral view after anterior interbody fusion with a bovine dowel at the C5/6 level. A halo around the dowel can be seen indicating that no real bony fusion or bone ingrowth into the dowel has occurred. (b) Roentenogram of the same patient in anterior-posterior view. The margin of the dowel is clearly seen which can be interpreted as a lack of real bony fusion

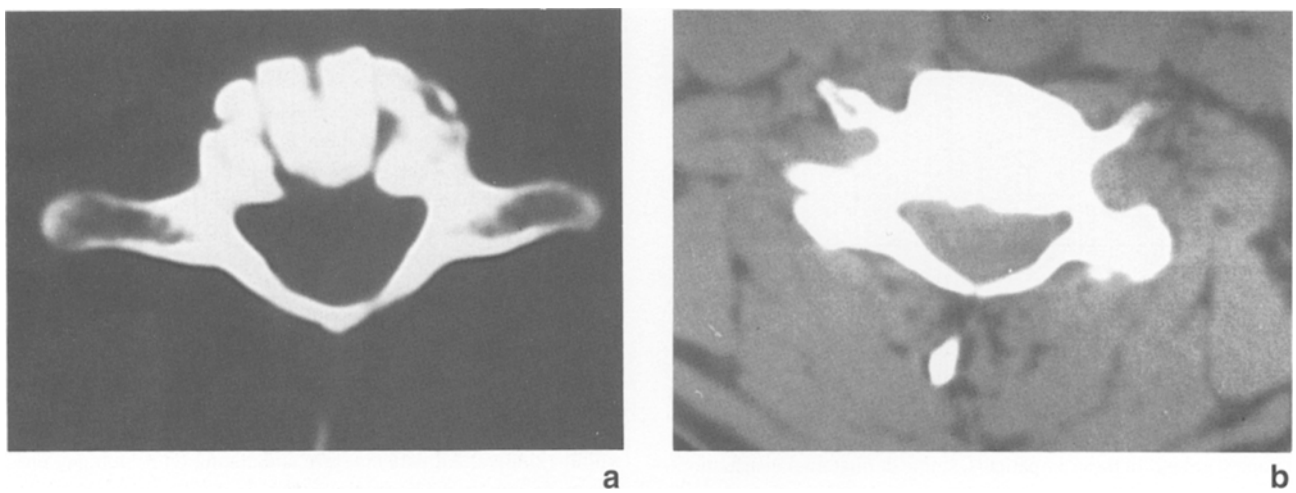


Fig. 2. (a) Typical CT appearance of a bovine dowel after anterior interbody fusion. Note the halo around the dowel, it demonstrates that no bony fusion has occurred. (b) A CT scan of a patient who received an autologous dowel from the iliac crest for interbody fusion. The bony structure is continuous between the vertebral body and the implant. A real bony fusion has been reached

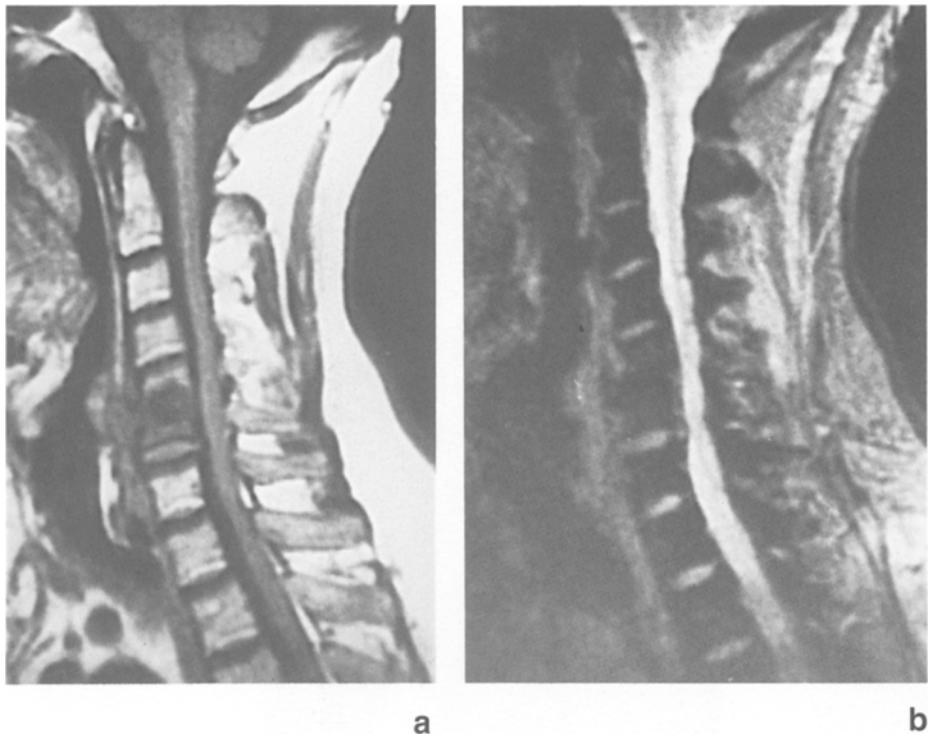


Fig. 3 (a) A T1-weighted MRI (1,5 T, SE 600/20) taken 1 year after implantation of a bovine dowel at the C5/6 level. The dowel appears as a hypo-intense signal suggesting lack of bony ingrowth from the adjacent vertebral body. (b) The T2*-weighted MRI of the same patient as in (a) (1,5 T, FE 600/25, flip 20°)

patients, the pain was relieved and the motor power improved within 6–12 months. All patients were seen in the outpatient clinic for neurological examination and x-ray six weeks postop. Table 5 shows residual symptoms after one year follow-up. Patients who had recurrence of symptoms were evaluated by CT and MRI. In these examinations a unique appearance of the dowel was detected. CT-scans showed a hypo-dense "halo" around the dowel (Fig. 2 a) and MRI depicted hypo-intense signals of the dowel in T1 and T2* studies (Fig. 3 a, b). This finding led to a series of postoperative CTs and MRIs in asymptomatic patients that all revealed the same appearance of the dowel up to 4 years after implantation.

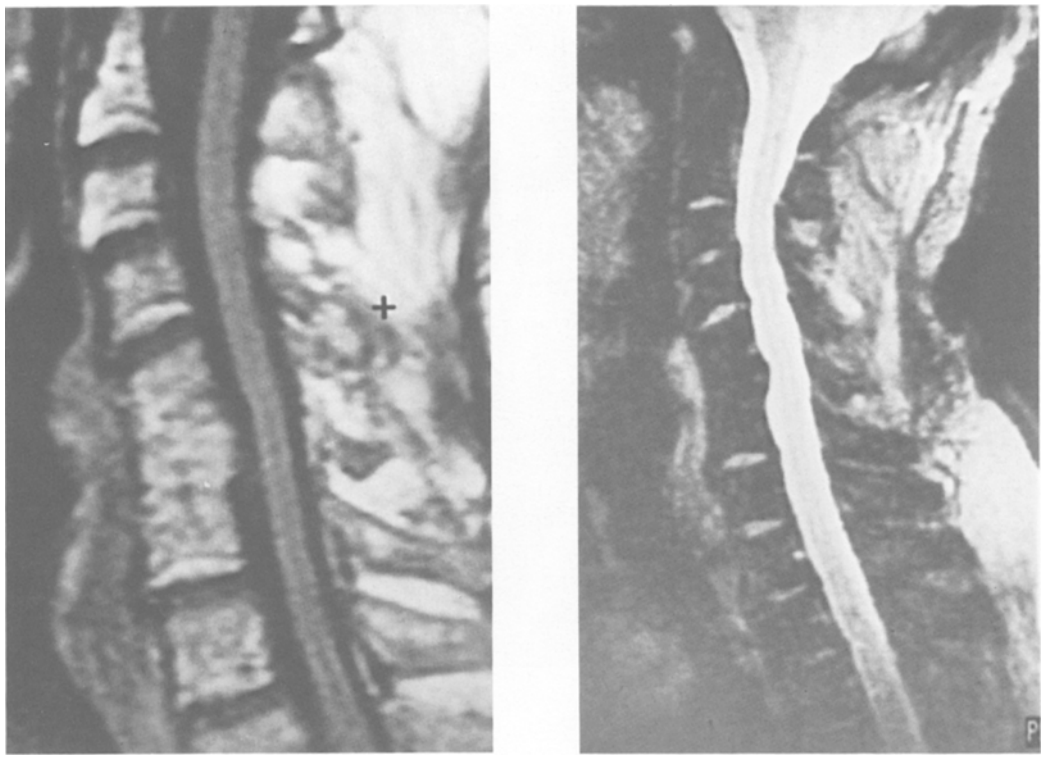
Table 5. *Residual Symptoms After a One-Year Follow-up (n = 66)*

Residual symptoms	No. of patients	%
Radicular pain	7	11
Unspecific shoulder pain	3	5
Hyp- or paraesthesia	6	9
Radicular motor weakness	6	9
Myelopathy	3	5
Dysthymia	1	2

Discussion

Since the anterior body fusion after discectomy has become a standard operation for cervical disc disease and cervical stenosis, many different materials have been used for fusion [5, 6, 12, 20]. Our clinical results using bovine dowel for the anterior body fusion were comparable to those reported in the literature. Taheri *et al.* [25] noted 87.5% excellent or good and 12.5% fair or poor results in their series which used the same outcome criteria. Riley *et al.* [18] reported good or excellent results with one- or two-level fusion in 72% patients using the Smith-Robinson fusion. Simmons *et al.* [24] reported an 81% good or excellent results when they used a keystone-shaped fusion. Grossmann *et al.* [12] had 83% patients with excellent or good results in one, two, or three levels using a freeze-dried fibula allograft. Our series has a success rate which is comparable to those mentioned.

Advantages of using a carved bone dowel include decreased operation time, decreased pain since no donor site is necessary, avoidance of morbidity associated with the iliac bone harvest, and the fact that the bovine dowel is a standardised product which is sterilised and tested for compression (see also Unilab



a b

Fig. 4. (a) MRI-appearance of autologous bone implant at the C5/6 level. The signal of the dowel resembles the signal of vertebral bone much more than seen on Fig. 3 a suggesting bony ingrowth from the adjacent vertebral bodies. (1,5 T, SE 600/20). (b) T2-weighted MRI of the same patient as in (a). The appearance of the autologous bony implant is comparable to the heterologous implant depicted on Fig. 3 b suggesting that T2-weighted images do not show the halo as clearly as T1-weighted images

product information). The average time of surgery using bovine dowel was 100 minutes compared to 205 minutes when autologous bone implants were used in a previous series.

No immunological incompatibility with bovine dowel has been reported. Taheri [25] reported that Kiel bone [6, 15] is "not only tolerated by the host with no reaction, but is also completely transformed into living bone tissue, if it is in sufficiently close contact with the surrounding live bone". The conclusion was based upon the cervical AP-roentgengram which demonstrated a "halo" [25] surrounding the bovine dowel. We observed the same "halo" on plain x-ray films (Fig. 1 a, b). In our postoperative CT studies we also found a ring around the bovine dowel (Fig. 2 a) which is clearly in contrast to a CT scan typically seen after implantation of autologous bone (Fig. 2 b). This finding that the Surgibone^R graft was not completely incorporated into the adjacent vertebral bone was also described by others. Säveland *et al.* concluded that use of bovine chips for posterior occipito-cervical fusion does usually not lead to predictable bone union [21] but still reported on good clinical outcome. In a more detailed study, Rawlinson compared autologous bone grafts with Surgibone^R grafts in a prospective study [17]. In the first part of their paper they reported on a significant increase of morbidity because of pain related to the autologous donor site at the iliac crest. In the second part they concluded that Surgibone^R is not an adequate substitute for autologous bone graft in cervical fusion because it does not achieve bony fusion at all or only after a long delay. Furthermore, they reason that the bovine allograft frequently was associated with development of mechanical pain in the neck. Of great interest are the histological examinations performed by Rawlinson. In three of their 49 patients with Surgibone^R grafts did they have to re-operate, in one of them because of an infection. On histological sectioning signs of inflammatory or giant cell reactions were

found in an area which corresponded to the "halo" described above. Also, they described a lack of cell lining or new osteoid formation on the Surgibone^R trabeculae.

According to the manufacturer of Surgibone^R (Unilab) up to 27% of bound proteins are still present after preparation of this bovine dowel but this protein does not contain any antigenic properties (personal communication with Unilab). This was underlined by several animal experiments conducted in the 1970s before clinical introduction of Surgibone^R (literature available from the company). Nevertheless, in patients this bovine dowel clearly produces a reaction that is different than that to autologous bone. The "halo" on X-rays and CT images indicate that the dowel was detected as a foreign body. The addition of MRI leads one to believe that this "halo" represents fibrous tissue and not bone structures growing into the dowel (Fig. 3 a, b) as seen after implantation of autologous material (Fig. 4 a, b). In T1-weighted images the dowel appears as a hypo-intense signal with a clear demarcation of the normal cervical vertebral bone suggesting a lack of incorporation of the Surgibone^R structures into living bone tissue. The MRI also showed that the specific bovine dowel structure was maintained over at least 4 years postoperatively. Lymphocytes and giant cells in histological slices of Rawlinson's work showed that indeed the "halo" area is comprised of fibrous and inflammatory elements. These findings are therefore in contrast to Taheri's report and challenge a concept which has not been questioned for 22 years.

In conclusion the question arises if this unique response to bovine dowel material is of any clinical importance. It is Rawlinson's opinion that this "halo" could be responsible for development of mechanical instability. This is not really conclusively reported by the authors since this "complication" led to only one re-operation and in contradiction many reports in the literature and to our findings with good outcome in the majority of patients after bovine dowel implantation. We therefore believe that a "halo" around the bovine dowel is without clinical significance. We plan to continue research in that area and have started a series of follow-up examinations with x-ray and MRI in order to quantify the changes seen. Obviously, more histopathological examinations especially after several years of implantation will give the final word on the actual histological structure and host-to-graft reactions of the implantation dowel.

Conclusions

1. Bovine dowel implants yield comparable clinical results to autologous bone implants in terms of the patient's symptoms.
2. Conventional x-rays demonstrate good stability of the spine with bovine implants.
3. CT scans of the implant show a "halo" which could represent fibrous tissue.
4. MRI suggests no replacement of the dowel with "living tissue", contrary to earlier reports in the literature.

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