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Short communication

# Hydroxyapatite Ceramics in Multilevel Cervical Interbody Fusion – Is There a Role?

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**A B S T R A C T**

*The aim of this study is to evaluate the efficacy of hydroxyapatite grafts in multilevel cervical interbody fusion during the one year follow-up. A total of 86 patients with degenerative cervical disc disease underwent all together 224 cervical interbody fusion procedures in which either Smith-Robinson or Cloward type hydroxyapatite grafts were used. The surgeries included radiculopathy in 38 cases, myelopathy in 20 cases and myeloradicuopathy in 28 patients. In 65 out of 86 patients, fusion was followed by an anterior instrumentation (plating). Postoperatively, patients were followed for a mean of 15.64 (range 11–23.3) months. All patients underwent radiography to evaluate fusion and the axis curvature. Excellent clinical results (86%), described as a complete or partial relief of symptoms with full return to preop activity, were obtained in patients with radiculopathy. There were 5 grafts mobilizations and one graft fracture. Two grafts extruded in non-instrumented patients and required repeated surgery. There were other three reoperations due to the hardware problems. One year fusion rate was obtained at 86% for two-level surgery, 80.1% for three-level surgery and 74% for four-level surgery. The mean (SD) hospital stay was 3.8 (0.7) days. A hydroxyapatite cheramic can be a very effective synthetic material for multilevel cervical interbody fusion. It is characterized by a high fusion rate and a small percentage of graft-related complications, especially when fusion procedure is followed by plating.*

***Key words:*** *multilevel cervical spondylosis, fusion, hydroxyapatite, instrumentation, one year follow-up*

## Introduction

While anterior microdiscectomy, with or without fusion, is considered to be sufficient for treating single level cervical disc problem[11,22,24,27,30] by many authors, in multilevel spondylotic patients, interbody fusion and more likely instrumentation is required. Therefore, in obtaining fusion, the role of the graft material has always been very important. However, the quality of the fusion depends not exclusively on the properties of the interbody graft, but also on the graft placement technique. The autologous bone has been shown to induce the best solid fusion. However, it can be the source of frequent complications (donor site pain, infections…) related to its harvesting predominantly at the iliac crest[19,34]. These complications can be avoided when allografts are replacing the autologous bone, but that may be associated with a lower fusion rate and a high risk of graft collapse[1,2]. Some authors even believe that the majority of synthetic materials[14,21,25] do not provide adequate fusion at all. A hydroxyapatite graft (HA), a pure synthetic calcium hydroxyapatite, has the advantages of osteoconductive properties[8], good resistance, simplicity of use, low price and a physiological shape[3]. The aim of this study was to evaluate the quality of the fusion of HA grafts in multilevel cervical spondylosis surgery during the one year follow-up.

## Patients and Methods

In the period of November 2002 to October 2004, 86 consecutive patients, aged 19–78 years (median 56.4) underwent anterior cervical discectomy and interbody fu-

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sion with hydroxyapatite grafts. Alltogether 224 cervical interbody fusion procedures were performed in which either Smith-Robinson[33] or Cloward type[6] of grafts were used. Indications for the surgery included radiculopathy (38 cases), myelopathy (20 cases) and a combination of the two (28 patients). A two-level fusion was performed in 44 patients (37 patients C5-C7, 5 patients C4-C6, and 2 patients C3-C5); a three-level fusion was performed in 32 patients (8 patients C3–C6 and 24 patients C4–C7), and a four-level fusion was performed in 10 patients (all at C3-C7).

In 65 out of 86 patients, fusion was followed by plating. In 43 patients, a Codman plate with a screw locking device (Johnson and Johnson, Raynham, MA USA) was used. In 22 cases, the EBI Spine Link plating system (Biomet Company, New Jersey, USA) was used. In all instrumented patients, cervical interbody fusion was performed using the Smith-Robinson type of grafts. Plating was not performed in 21 patients. There were 15 patients (7 two-level fusion, 4 three-level fusion, and 4 four-level fusion) where Cloward type of grafts were used for interbody fusion. There were also six patients with a two level Smith – Robinson type of fusion, where plating was not performed. Postoperatively, a soft cervical collar was applied for three months only in non-instrumented patients.

### *Surgical procedure*

Right-sided standard anterior cervical approach was performed. Skin incision was exclusively horizontal for the two-level surgery and longitudinal for the four-level surgery, while for the three-level surgery either one or the other of those two incision types were used. At the level of the anterior spine, first all of the osteophytes, including the anterior longitudinal ligament were removed. The disc was then completely removed and cortical bone was exposed. High-speed drill was used to flatten both end-plates. In the microsurgical standard technique, posterior spondylotic spurs were removed, and the posterior longitudinal ligament was opened to widely decompress neural tissue. After the placement of the Caspar intervertebral distractor, the hydroxyapatite graft was introduced into the disc space and positioned in a way to ensure maximal contact in between the cortical endplates.

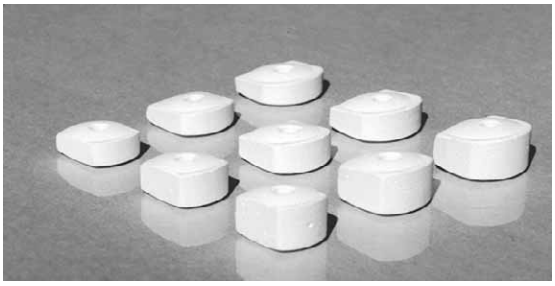

*Fig. 1. Hydroxiapatite grafts Smith-Robinson type. Note the pre-lordotic shape, three different graft heights and nine different dimensions.*

Hydroxyapatite grafts (Synatite-SBM, Toulouse, France) are available in various heights and widths. They have a trapezoid shape to maintain some degree of lordosis. Their superior and inferior surfaces are convex to fit the natural concavity of the vertebral endplates (Figure 1). The Cloward type of grafts have the dowel like shape in three different diameters (11, 12 and 13 mm). The size of the graft was determined to attain a slight distraction of the disc space, and it was chosen by an insertion of a metallic phantom for Smith-Robinson type of grafts. In Cloward technique of the fusion, the direct measurement between the two vertebral bodies was used to determine the graft diameter (dowel).

### *Clinical evaluation*

Postoperative clinical outcome was assessed according to Odom's classification[26]: an excellent or good result referred to a complete or partial relief of the symptoms with a full return to everyday activities; a fair result denoted improvement with some persistent limitation of activity; and a poor result indicated either no improvement or clinical deterioration after the surgery.

### *Pre and postop radiological assessment and follow-up*

Preoperative assessment included plain radiography, magnetic resonance imaging (MRI), EMNG study, and, in some cases, computerized tomography (CT).

All the patients underwent postoperative radiography to evaluate fusion, lordosis, and intervertebral disc height, as well as for the assessment of graft-related complications. Radiological fusion's criteria were defined as no transparency between the graft and the lower and the upper endplate, as well as the new bone formed behind the graft. Plain radiography was performed two days, three and six months, and one year after the surgery. Some patients with unclear evidence of fusion were followed yearly until the fusion was complete. The mean follow-up time was 15.64 (range 11–23.3) months. Lordosis was systematically analyzed in the early postoperative period, and the condition of the spine was compared with preoperative status. No patient was lost for follow-up.

### *Statistical analysis*

Statistical analysis was done using STATISTICA for Windows, Release 6.0.

Descriptive and nonparametric statistic was used (chi square test and extended Mantel-Haenszel chi square for linear trend). The level of statistical significance was set at $p \leq 0.05$.

## Results

According to the Odom's classification, the best results are obtained in patients with radiculopathy where excellent clinical outcome occurs in 86% of the patients. In the patients who presented preoperatively with either

**TABLE 1**
SUMMARY OF POSTOPERATIVE CLINICAL RESULTS IN PATIENTS WITH PREOPERATIVE SIGNS OF RADICULOPATHY AND/OR MYELOPATHY

| Clinical result* | No (%) of patients | |
|---|---|---|
| | Radiculopathy (n=38) | Myelopathy (n=48) |
| Excellent | 33 (86) | 9 (19) |
| Good | 3 (8) | 13 (27) |
| Fair | 2 (6) | 21 (44) |
| Poor | none | 5 (10) |

*According to Odom's classification (26)

radiological or clinical signs of myelopathy, postoperative clinical results were less desirable compared to the patients with radiculopathy ($\chi^2$=40.04, p<0.0001). See Table 1.

Postoperative radiological results related to the graft status are presented in Table 2. There were, in addition, 8 graft fractures, but none of them required new surgery. Two grafts extruded in non-instrumented patients and required surgery. There were another three reoperations due to the hardware problem and pseudoarthrosis. One year fusion rate was obtained at 86% for two-level surgery, 80.1 % for three-level surgery and 70% for four-level surgery ($\chi^2$=110.6; p<0.001) with clearly the best results for the two-level surgery (extended Mantel-Haenszel $\chi^2$ for linear trend=90.66; p<0.0001). Mean (SD) hospital stay was 3.8 (0.7) days.

Postoperative radiological assessment had shown lordosis in all of our cases, even in patients presenting with preoperative kyphosis or long straightening of the cervical spine. We observed no graft collapse, although there was a minimal (less than 2 mm) graft deterioration in 27 out of 54 fusions in non-instrumentated patients. Graft fracture without displacement was seen in 8 out of 86 patients. There was no correlation between these radiological findings and the fusion rate or clinical outcome. Newly formed bone deposits were seen behind the graft in all of the patients. These deposits enlarged in time, and made a complete bone bridge between the two endplates (Figure 2).

**TABLE 2**
RADIOLOGICAL POSTOPERATIVE FUSION RATE AND THE GRAFT STATUS WITH THE CLEARLY BEST RESULTS FOR TWO-LEVEL SURGERY

| One year fusion rate* | No (%) of patients |
|---|---|
| 2-level discectomy (n=44) | 38 (86) |
| 3-level discectomy (n=32) | 26 (81) |
| 4-level discectomy (n=10) | 7 (70) |
| Graft status* | |
| Pseudoarthrosis | 3/86 (3.5) |
| Extrusion | 2 /21 (9.5) |
| Fracture | 8/86 (9.3) |

*According to independent radiologist

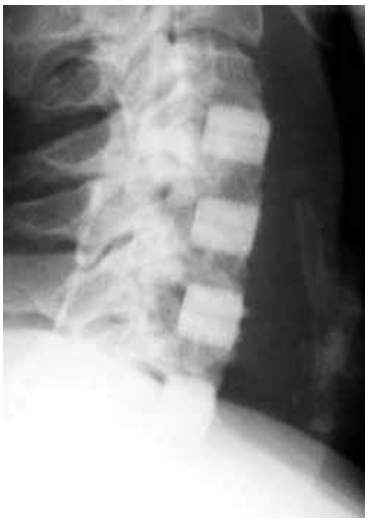

*Fig. 2. A four level complete cervical fusion at 18 months follow--up in non- instrumentated patient.*

## Discussion

This study has demonstrated that hydroxyapatite (HA) is very effective in inducing cervical interbody fusion. The rate of complete fusion at one year follow-up was 86% for the two-level surgery, 81.1% for the three-level surgery and 70% for the four-level surgery, respectively. This is comparable, or even superior to that what is reported in the literature when other grafting methods were used.

After the introduction of anterior approaches in the 1950s by Smith and Robinson[33], and Cloward[6], anterior cervical interbody fusion has been broadly used with various types of grafts to treat multisegmental spondylosis[5,12,28,29,32,35]. It was always stated that a good graft should not only induce a rapid and complete interbody fusion, but also restore physiological lordosis, intervertebral and foraminal heights[13,36]. It is due to the chemicophysical characteristics of the HA graft to satisfy these goals. The HA ceramics are composed of hydroxylized calcium phosphate and are chemically identical to the natural HA of the bone[15,17]. The process of mixing these materials leads to the formation of the porous ceramics with high osteoconductive properties. The graft is invaded by newly formed bone that grows directly into the pores[7,8]. Resorption of the HA is very limited in both cell- and solution-mediated processes, in contrast to the tricalcium phosphate compounds (TCP), which are rapidly resorbed[8,15,17]. Preliminary clinical results with the HA grafts were published in 1986 by Koyama and Handa[18]. This study is one of the first to report the usage of the HA grafts in multilevel spondylosis combined with plating. In three patients, we have observed hardware failure (two patients with three-level and one patient with four--level surgery), and although no spinal instability was noted during a long-term follow-up, a repeated surgery was carried out because of the swallowing problems

and/or significant cervical pain. We have also found that the trapezoid shape of the HA grafts allowed the correction of all preoperative segmental kyphotic deformities. Physiological lordosis was noted postoperatively in all of the patients, and persisted throughout the long-term review. Furthermore, intervertebral and foraminal heights were maintained until the fusion was complete, and no graft collapse occurred. This observation can be explained by the resistance of the HA material to axial load and an absence of the HA resorption. Therefore, no subsidence was observed. Clinical results were satisfactory, and comparable with those obtained in other studies in which anterior surgical decompression and fusion were conducted[9,13,16,20,22–24]. Postoperative results in our series are significantly better in patients with radiculopathy. Postoperative results in patients who presented with myelopathy or myeloradiculopathy were not that satisfactory compared to the patients with radiculopathy, probably due to the natural history of the myelopathy, which has a progressive course. Surgery was performed too late in some cases, when an irreparable damage had occurred in the spinal cord and patients had little or no clinical improvement from the decompression. The clinical goal of the surgery in these cases was to stop the progressive clinical deterioration, and to remove the compression from the spinal cord. Despite the complications observed radiologically after the surgery, neither neurological deterioration was observed, nor those complications affected the fusion rate.

Hydroxyapatite grafts, in general, offer many advantages over the other grafts types. Iliac crest autograft is associated with a significant donor-site morbidity, and pain in particular[19,34]. Using the Smith-Robinson technique, Bohlman[2] found pseudarthrosis in 13% of patients, 8% of whom required reoperation. Although some authors have found no relation between pseudoarthrosis and fusion status, others have reported that the quality of the fusion was considered to influence the clinical outcome significantly, suggesting that the motion at the level of the pseudarthrosis may contribute to residual nerve root compression[2,36]. In our experience, once developed, pseudoarthrosis causes only prolonged and significant neck pain which decreases the range of the cervical spine motion, requiring day after day medication. Conservative treatment is usually a good option for the pseudoarthrosis patients if there is no neurological deterioration.

In many studies in which autografts and allografts are used, the fusion rate statistically decreased as the number of the fused levels increased[2,3,10]. These observations have occurred with hydroxyapatite grafts, and have been confirmed by this study, where in four-level patients the fusion rate was only 70%, but that is probably the case with any graft in use, and should not be a reason to avoid the usage of ceramics in multilevel cervical interbody fusion.

Question still remains concerning the anterior plating combined with the usage of the HA grafts. In our experience, and as it was suggested in the literature[16,31], the main goal of using the plate is to ensure immediate stability and to prevent the graft extrusion or fracture, by reducing the distortional forces applied to the graft during spinal movements. In 1998, Kim[17] described the usage of a HA graft without a cervical plate in 70 patients. In three cases, anterior or posterior graft dislocation required re-operation. In our study, in 2 out of 11 non-instrumented patients, where fusion was performed by Smith Robinson type of graft, anterior graft extrusion was noted and another surgery had to be performed. Question also remains, whether the graft expulsion had occurred because of the graft characteristics or because of an inappropriate surgical bed preparation. No graft extrusion was noted when the fusion was performed with Cloward type of grafts, or when the plating was added after the fusion. We did not notice a posterior displacement neither of the Smith-Robinson, nor of the Cloward type of grafts. This was also confirmed by the study of Brunea et al.[4], in which 68 fusion procedures with HA grafts were performed, but no graft mobilization was reported. In our study, the graft deterioration (anterior mobilization up to 2 mm) happened exclusively in patients in whom anterior plating was not used. Although the radiological signs of the grafts' deterioration had no influence on the clinical outcome, a rather high incidence (up to 50%) of the HA grafts' mobilization in non-instrumented patients clearly suggests the need for plating.

## Conclusion

Hydroxyapatite grafts are a very effective synthetic material for multilevel cervical interbody fusion. They have the fusion rate as high as the other types of grafts (allo or auto), and a small percentage of the graft-related complications when fusion is followed by anterior plating.

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## HIDROKSIAPATITINI GRAFT KOD VIŠERAZINSKE VRATNE INTERVERTEBRALNE FUZIJE – KAKVA JE ULOGA?

### S A Ž E T A K

Cilj rada je procijeniti učinkovitost hidroksiapatitnog grafta u primjeni višerazinske vratne intervertebralne fuzije nakon perioda praćenja od godinu dana. Osamdeset šest pacijenata s degenerativnom bolešću vratnog diska operirano je na ukupno 224 razine, a korišteni su ili Smith-Robinsonovi ili Clowardovi tipovi hidroksiapatitnog grafta. Indikacije za kirurško liječenje su uključivale radikulopatiju u 38 slučajeva, mijelopatiju u 20 slučajeva ili kombinaciju u 28 slučajeva. Kod 65 pacijenata rađena je i instrumentacija. Poslijeoperacijski su pacijenti praćeni prosječno 15,64 mjeseca (raspon 11–23,3 mjeseca). Svi pacijenti su radiološki praćeni da bi se procijenio stupanj fuzije te zakrivljenost kralježnice. Odlični rezultati u obliku potpunog ili djelomičnog olakšanja simptoma dobiveni su kod pacijenata s radikulopatijom. Bilo je 5 slučajeva pomaicanja grafta te jedan slučaj frakture istog. Dva pacijenta zahtjevala su reoperaciju radi mobilizacije grafta. Bile su potrebne još tri reoperacije radi problema s ugrađenim materijalom te posljedičnim razvojem pseudoartroze. Nakon jedne godine fuzija je postignuta u 86% bolesnika s dvorazinskom, 80,1% bolesnika s trorazinskom te 74% bolesnika s četverorainskom bolešću. Prosječno vrijeme hospitalizacije bilo je 3,8 dana. Hidroksiapatitni graftovi mogu biti izvrstan sintetski materijal kod višerazinske vratne intervertebralne fuzije. Karakteriziran je visokim postotkom fuzije i malim postotkom komplikacija osobito ako se radi i instrumentacija.