

Calcium Sulfate

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Calcium Sulfate as a Graft Substitute for Spinal Fusion

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– Abstract –

Study design : This is a prospective study to determine whether calcium sulfate(CS) used as a bone graft expander could promote spinal fusion as effectively as autogenous bone graft.

Objectives : To investigate the ability of CS to serve as bone graft substitute when combined in a 1:1 ratio with autogenous graft bone(AGB).

Semmary and Literature Review : Autogenous bone is considered the most successful bone graft material and is presently gold standard. Many complications, however, have been reported. Thus, numerous biodegradable osteoconductive ceramic bone graft substitute have received attention as alternative to autogenous bone to reduce the complications. The advantage of a biodegradable graft material is its compatibility with the new bone remodeling process required to attain optimum mechanical strength.

Materials and Methods : Fifteen patients who had undergone posterolateral spinal fusion with instrumentation using CS mixed with AGB were evaluated. The patients received the autogenous iliac crest graft on one side of the spine and an equivalent volume of autogenous iliac crest/ CS combination on the other side. Thus, the patients serve as their own control. The number of segments fused was 45 segments. The implanted sites were assessed for new bone formation and bony fusion by plain radiography and CT.

Results : Of 47 segments fused with CS and AGB, 42 segments (89.4%) were completely fused. In contrast, segments fused with AGB alone, 44 segments (93.6%) were fused. One patient showed nonunion at the both side. Two patients had nonunion at the fused segments with CS and AGB. However, the other side showed complete union. 5 patients who underwent removal of hardware had grossly and histologically complete union. There were no complications related to CS.

Conclusion : Calcium sulfate appeared to have some potential as a bone graft expender rather than a graft substitute when combined 1:1 ratio with AGB, despite fusion rate by CS mixed with AGB ws lower than AGB alone.

Key Words : Fusion, Osteoconduction, Calcium sulfatfe, Graft substitute

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15
14 38 30.1
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56 가3 가12
가 가
, 25~30% , 5%~35%
19,24)
1 1 2 4
1 4-10 1 9
- 2 1 10 - 3 1 1 - 5
3 2-5 1 2-4 3 4-5 1
가 3,4,21,22)
, 3 - 1 1 3-5 3
47 3.1 CS
가 TSRH
(demineralized bone matrix : DBM)¹⁰⁾,
(bone morphogenic protein : BMP)^{4,21,22)} calcium
phosphate⁵⁾ 가
(biodegradable)
tricalcium phosphate, hydroxyapatite, calcium sulfate(CS)^{5,7,8,11)}
가⁷⁾
12
Lenke¹³⁾ 4가
2 mm
CS 40
CT
15-17)
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1. calcium sulfate

CS 2 6
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1997 11 1998 10 calcium sulfate(Ostose Pellet, Wright Medical Inc., U.S.A)
4 3 CS
Fisher's Exact
1

Table 1. Summary of Clinical Data

Pt. No.	Sex	Age	Diagnosis	Fusion Level	Combined Interbody fusion	Nonunion		Follow-Up period	Removal of hardware	Cx.
						Calcium Sulfate	A.B.G.			
1	F	53	Flexion-distraction injury, L3	L2-L4	-	-	-	18 mo.	+	-
2	F	59	Deg. scoliosis with stenosis, L2-5	L1-L5	-	-	-	14 mo.	-	-
3	F	27	Flexion-distraction injury, L1-2 Fx. burst L2	T10-L3	-	-	-	20 mo.	+	-
4	F	52	Flexion-distraction injury, L2-3	L2-L4	-	-	-	18 mo.	+	-
5	F	28	Tbc spondylitis, T6,7	T4-T10	+	-	-	35 mo.	+	-
6	F	73	spinal stenosis, L3-5 with seg. instability	L3-L5	-	-	-	35 mo.	-	-
7	F	60	Retrospondylolisthesis, L3 on L4 Deg. scoliosis with stenosis & seg. instability, L3-5	L3-L5	-	-	-	28 mo.	-	-
8	F	66	Deg. scoliosis with stenosis & seg. instability, L1-5	L1-L5	-	+(2)	+(3)	28 mo.	-	-
9	F	77	Spinal stenosis, L3-5 (FBSS)	L3-L5	-	+(2)	-	39 mo.	-	-
10	F	50	Isthmic spondylolisthesis, L4 on L5 with stenosis	L4-L5	+	+(1)	-	39 mo.	-	-
11	F	51	Spinal stenosis, L2-3 (FBSS)	L1-L5	+	-	-	38 mo.	-	-
12	M	30	Fx. & D/L. D12- L1 (FBSS)	T9- L2	+	-	-	37 mo.	+	-
13	F	65	Spinal stenosis L3-S1 (FBSS)	L3-S1	+	-	-	35 mo.	-	-
14	M	79	Deg. scoliosis with stenosis, L2-S1 Isthmic spondylolisthesis, L5 on S1	L2-L5	-	-	-	34 mo.	-	-
15	M	70	Spinal stenosis, L2-5 (FBSS)	L2-S1	-	-	-	33 mo.	-	Cb. infarction

*FBSS : Failed back surgery syndrome

() : numeric number means nonunion segment

Cx. : complication

Assessment of fusion according to Lenke's classification

A : Indicates a big, solid trabeculated bilateral fusion mass(definitely solid)

B : Big, solid unilateral fusion mass with a small contralateral fusion mass(possibly not solid)

C : Small, thin bilateral fusion mass with an apparent crack(possibly not solid)

D : Bilateral resorption of the graft with an obvious bilateral pseudoarthrosis(not solid)

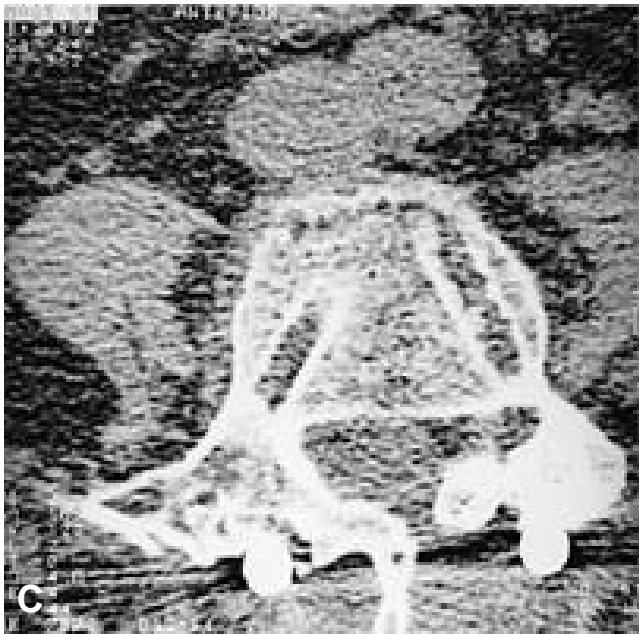
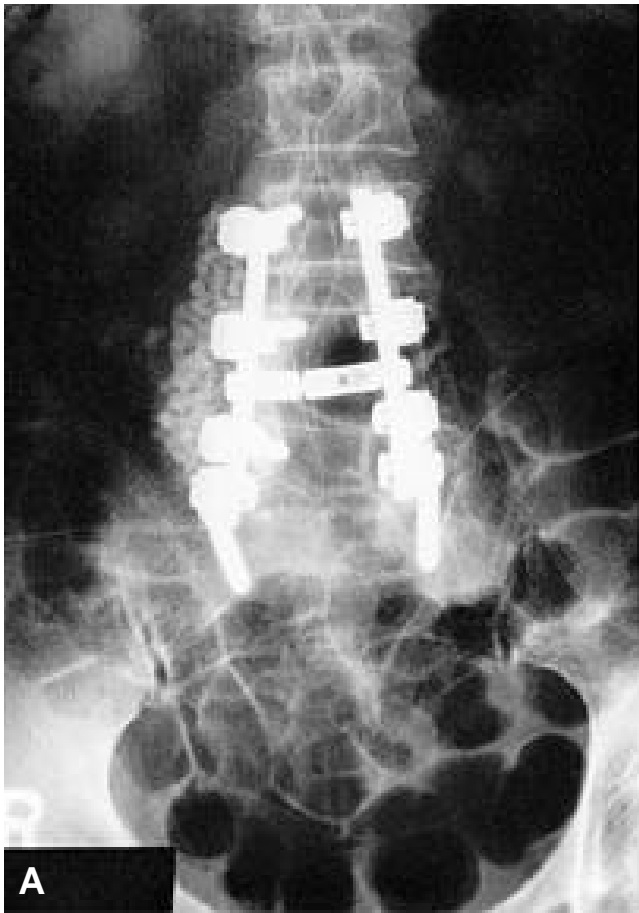


Fig. 1-A. Postoperative roentgenogram

B. Postoperative 2 years. Complete union was noted in both graft sites.

C. On CT finding, there was bone formation on both transverse processes.

2. 가 47

CS 44 (93.6%) , 가 42 (89.4%)

(Fig. 1A-C).

15 1 , CS

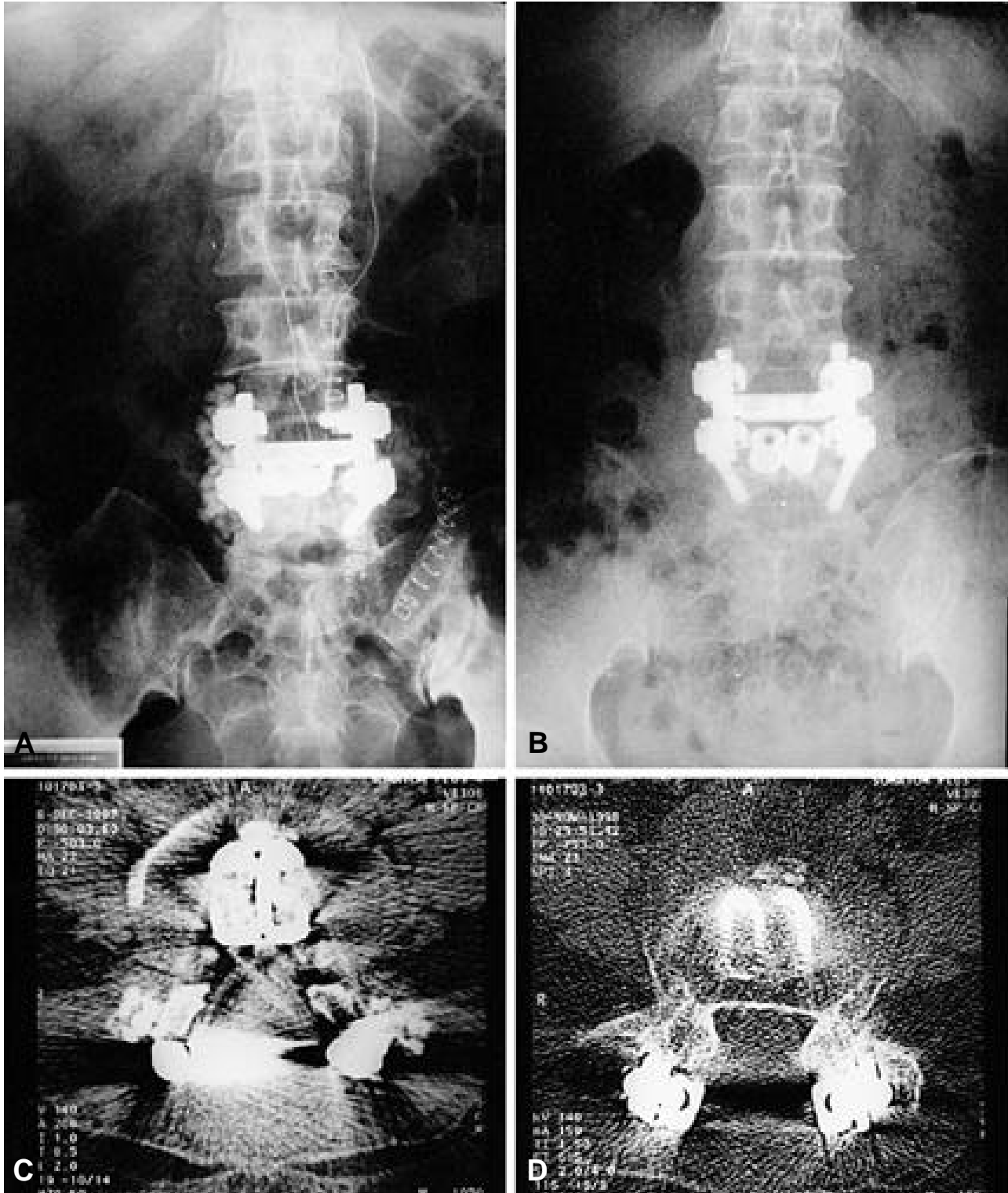


Fig. 2-A. Postoperative roentgenogram

B. Postoperative 28 months. Calcium sulfate site was completely resorbed and showed nonunion.

C,D. No bony union in CS mixed with autogenous bone graft site, but were showing bony union on autogenous bone graft site.

2 가 3 3 가
4 . 2 3
가 , CS
2 3
4 (Fig. 2A-D). CS



Fig. 3. Showing multiple pores in CS mixed with AGB site(Rt) as compared with autogenous graft(Lt) on gross findings.

3.
5
1 CS
(Fig. 3).
가 (Fig. 4A-B).
4.
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1
4
가 가 3-5,9,10,14,22)
Jarcho¹²⁾

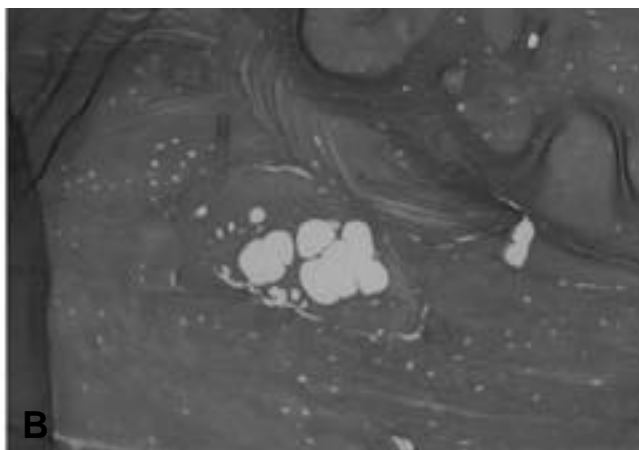
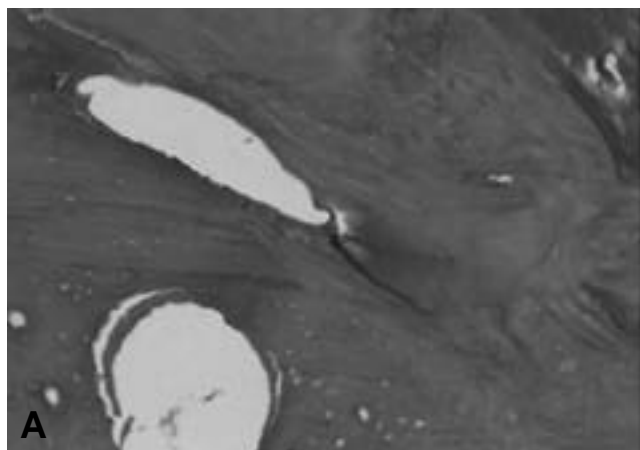


Fig. 4. Showing bony trabeculae. But osteocytes were not visible. There was no histologic difference between both groups in matrix ($\times 100$, H-E staining). A: AGB site, B: CS mixed with AGB site

3,8) .
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, Delecrin²⁰⁾ 8) CS ,
가 89.4% ,
, Yamazaki²³⁾ CS
, 1) CS CS 가
, 가 CS
Sidqui¹⁸⁾ 가 CS 가 CS CS
, CS가 creeping substitution
Hadjipavlou¹¹⁾ titanium mesh CS 가 CS
1) TNF- 가 TNF- 가 가 CS
Nikulin Ljubovic¹⁵⁾ 가 CS가 , Bell²⁾ 가 , 가
5~7 CS가 CS 89.4% 93.6%, 가
Cotezee⁶⁾ CS , 5 CS
가 6 CS가 2 가
4 3 가
Peltier⁶⁾ CS CS CS
가 CS 가
CS 가
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1 CS 가 CS 가
가 5 , 가 가
, Peltier Lillo¹⁷⁾ CS
CS 45~72 CS CS
CS 가

CS

가

REFERENCES

- 1) , : *calcium sulfate* , 6:336-343, 1999.
- 2) **Bell WH** : Resorption characteristics of bone and plaster. *Oral Surg*, 39:727, 1960.
- 3) **Boden SD, Martin GJ, Morone M and et al** : The use of coralline hydroxyapatite with bone marrow, autogenous bone graft, or osteoinductive bone protein extract for posterolateral lumbar fusion. *Spine*, 24:320-327, 1999.
- 4) **Boden SD, Schimandle JH and Hutton WC** : Lumbar intertransverse-process spinal arthrodesis with use of a bovine bone-derived osteoinductive protein: A preliminary report. *J Bone Joint Surg*, 77A:1404-1417, 1995.
- 5) **Bucholz RW, Carlton A and Holmes RZ** : Hydroxyapatite and tricalcium phosphate graft substitute. *Orthop Clin North Am*, 18:323-334, 1987.
- 6) **Coetzee AS** : Regeneration of bone in the presence of calcium sulfate. *Arch Otolaryngol*, 106:405-409, 1980.
- 7) **Delecrin J, Aguado E, Nguyen JM, Pyre D, Royer J and Passuti ZV** : Influence of local environment on incorporation of ceramic for lumbar fusion. Comparison of laminar and intertransverse site in a canine model. *Spine*, 22:1683-1689, 1977.
- 8) **Delecrin J, Takahashi S, Gouin F and Passuti N** : A synthetic porous ceramic as a bone graft substitute in the surgical management of scoliosis. *Spine*, 25:563-569, 2000.
- 9) **Ferraro JW** : Experimental evaluation of ceramic calcium phosphate as a substitute for bone grafts. *Plast Reconstr Surg*, 63:634, 1979.
- 10) **Frenkel SR, Moskovich R, Spivak J., et al** : Demineralized bone matrix: Enhancement of spinal fusion. *Spine*, 18:1634-1639, 1993.
- 11) **Hadijivavlou AG, Simmons JW, Youg J, Nicodemus CL, Esch O and Simmons DJ** : Plaster of Paris as an osteoconductive material for interbody vertebral fusion in mature sheep. *Spine*, 25:10-16, 2000.
- 12) **Jarcho N** : Calcium phosphate ceramics as hard tissue prosthesis. *Clin Orthop*, 157:259-278, 1981.
- 13) **Lenke LG, Bridwell KH, Baldus C, Shoeneker PL., et al** : Results of in-situ fusion for isthmic spondylolisthesis. *Federation of spine association 7th Annual meeting, Washington D.C.*, 23-24, 1992.
- 14) **Holmes R, Mooney V, Bucholz RW and Tencer A** : A coralline hydroxyapatite bone graft substitute. *Clin Orthop*, 188:252-262, 1984.
- 15) **Nikulin A and Ljubovic E** : Der gipsstift in der experimentellen kochen regeneration. *Acta Chir Scand*, 91:17-27, 1944.
- 16) **Peltier LF** : The use of plaster of Paris to fill defects in bone. *Clin Orthop*, 21:1-31, 1961.
- 17) **Peltier LF and Lillo R** : The substitution of plaster of Paris rods for portions of the diaphysis of the radius in dogs. *Surg Forum*, 6:556-558, 1955.
- 18) **Sigqui M, Collin P, Vitte C and Forest N** : Osteoblast adherence and resorptive activity of isolated osteoclasts on calcium sulfate hemihydrate. *Biomaterials*, 16:1327-1332, 1995.
- 19) **Summers BN and Eisenstein SM** : Donor site pain from the ilium: A complication of lumbar spine fusion. *J Bone Joint Surg*, -B:667-680, 1989.
- 20) **Toth JM, An HS, Lim TH, Ran Y., et al** : Evaluation of porous biphasic calcium phosphate ceramics for anterior cervical interbody fusion in a canine model. *Spine*, 20:2203-2250, 1995.
- 21) **Urist MR** : Bone formation by autoinduction. *Science*, 150:893-899, 1965.
- 22) **Urist MR and Dawson E** : Intertransverse process fusion with the aid of chemosterilized autolyzed antigen-extracted allogenic (AAA) bone. *Clin Orthop*, 165:97-113, 1981.
- 23) **Yamazaki Y, Oida S, Akinoto Y and Shoida S** : Response of the mouse femoral muscle to an implant of a composite of bone morphogenic protein and plaster of Paris. *Clin Orthop*, 234:240-249, 1988.
- 24) **Younger EM and Chapman MW** : Morbidity at bone graft donor sites. *J Orthop Trauma*, 3:192-195, 1989.



: calcium sulfate (CS) 가 가

: CS

: CS 15 가

CS 가 1:1 30.1 가 가

CS 45 CT

: CS 가 47 42 (89.4%) , 가

47 44 (93.6%) . 1 , 2 CS

가 , 가

가 5 CS

: 가 ,

CS

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: 505

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