Bioactive Glass versus Autogenous Iliac Crest Bone Graft in Adolescent Idiopathic Scoliosis Surgery

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Abstract- Surgery on the skeleton frequently requires harvesting of autogenous bone graft from the pelvis, but this procedure is complicated by problems. The purpose of this retrospective, comparative descriptive study was to compare the efficacy of metal-derived bioactive glass (Novabone) versus autogenous iliac crest bone graft in adolescent idiopathic scoliosis surgery. The study was carried out on forty cases (aged 14-20 years) with 55 total curves fused for AIS. Posterior spinal fusion was performed using local bone grafts combined with autogenous iliac crest bone graft in 20 patients (group 1), and combined with Novabone in another twenty ones (group 2). The patients were observed for a minimum of 24 months after surgery, with a mean postoperative observation time of 34.7 months. The results were assessed clinically and radiologically. In group 1, average preoperative curve was 66° with immediate correction to 24.2° (59.7%) and final follow-up of 27.4° (54.3%), but in group 2 the calculated numbers included 63.8°, 25.8° (59.6%) and 28.4° (55.5 %) respectively. There were 5 indeterminate fusions (3 cases in group 1 and 2 in the other group), 1 acute infection, and 1 hook dislodgement in the synthetic group. These results justify and favor the use of bone substitutes for instrumented posterior spinal fusion in AIS. Potentially hazardous harvesting of pelvic bone is no longer necessary for such operations.

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Key words: Bone graft, adolescent idiopathic scoliosis, spinal fusion, bone substitute

Introduction

Harvesting autogenic or allogenic bone graft to increase the rate of arthrodesis during segmental instrumentation for adolescent idiopathic scoliosis is a standard procedure. Harvesting autogenous bone grafts from the pelvis is one of the standard procedures in spine surgery, but this procedure may be accompanied by complications because of a higher operative time, much more blood loss, and a higher incidence of symptoms relating to the donor sites (1). In literature, some authors put emphasis on the interest of allograft versus autograft; although the results seems comparable (2, 3), banked allograft bone is not often available in many countries for spinal surgery, it is inferior to autogenous bone, and it has some risks of bacterial contamination and viral transmission, although such risk is very small (4, 5). Bone graft substitutes such as metal-derived bioactive glasses (Novabone; Porex Surgical, Inc., Newnan, GA) have been used with success in various clinical applications for over 10 years (6). The success of the glasses is in part attributed to its bioactivity, which is a result of its composition (SiO_2, CaO, Na_2O, and P_2O_5). This combination attracts osteoprogenitor cells and osteoblasts, thus stimulates bone formation (7, 8). Clinically, Novabone has been used to reconstruct ear ossicles and dental and alveolar ridge defects (9, 10).

Benefits of these substances include safety, excellent bone bonding capacity, incorporation into native tissue, lack of donor harvest mobility, nonimmunogenic/noninfectious characteristics, smoother patient recuperation, and acceptable esthetic results (11). These materials, could be an alternative method to allogenous or autogenous grafting, but represent a significant cost (12, 13).

The purpose of this study was to assess the clinical

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performance of bioactive glass in spinal instrumentation surgery, as compared with the performance of autogenous iliac bone grafts.

Patients and Methods

This retrospective study was carried out on forty patients aged 14-20 years with 55 total curves fused for AIS in Shafayahyaiian Hospital, Tehran, Iran. The other criteria for inclusion in this study required that participants had major curves greater than 40° that were progressive, resistant to conservative treatment, and thus eligible for surgical treatment; had no other medical or skeletal disorders; had only posterior spinal fusion; and had no history of previous spinal surgery. The minimum long term follow-up accepted for this study was 24 months.[12] No patients with anterior surgery were included.

From March 1995 to January 1997, 20 consecutive patients that had these criteria were selected (group 1). In that time, we routinely added autogenous iliac crest bone graft to improve the rate of arthrodesis. From December 2004 to October 2006, another 20 consecutive ones (group 2) were selected. In the latest patients, instead of autogenous iliac crest bone graft, we added bone graft substitutes (Novabone).

Surgical techniques

All the operations were performed by the senior surgeons (I.A. and H.B.) according to the standard technique as described by Cotrel and Dubousset. Posterior fusion was performed by opening the facets; decorticating the laminae as well as the transverse and spinous processes; and grafting the following materials on the opened facets and decorticated surfaces: in the first group, autogenous bone chips obtained from the posterior iliac bone and local bone chips from the decortications; in the second group, 31cc of particles of NovaBone (size 90-710 microns) and local bone chips from the decortications. The costoplasty was not performed at the time of surgery.

During the operation, monitoring of spinal cord function was conducted by Stagnara wake-up test. After correction, fixation, and preparation of arthrodesis, the wound was sutured in three layers with a drainage tube in the subcutaneous space. Prophylactic antibiotics were administered during and immediately after the operation. After surgery, patients were allowed gradual return to full activities without cast or brace immobilization.

Assessment of results

Standing posteroanterior and lateral radiographs were assessed preoperatively, 7 to 10 days postoperatively, and at the last follow up.

We evaluated the efficacy of graft material for spinal fusion by two radiographic analyses. An analysis of the maintenance of the curve correction at the last term follow-up and an analysis to assess the fusion mass. Radiographically, the fusion status was rated as fused, indeterminate, or definite nonunion (14, 15). When there was absence of a solid fusion mass but no evidence of halo around the implant and absence of motion in flexion-extension lateral radiographs, it was classed as indeterminate. CT scan was not used for assessment of fusion.

Pseudoarthrosis was suspected if there was persistent localized pain, worsened with activity, relieved with rest, with either loss of correction >10°, and/or hardware failure and radiographic evidence of pseudoarthrosis (lack of bridging callus, areas of lucency, or lack of a solid fusion mass). Loss of 10° of correction has been previously identified as an indicator of potential pseudoarthrosis or fusion instability (16). No specific radiographic study to detect pseudoarthrosis has proven to be accurate >80% of the time (17).

To date, we have come across no entirely satisfactory method of accurately assess spinal fusion via radiologic means, so some authors and we chose to look at clinical outcome rather than base the results only on radiologic measures (18, 19). The number of operated levels was also measured, because it has been shown to significantly influence the fusion rate (20).

Statistics

Differences between the two groups were statistically analyzed by the Mann-Whitney test for the average values, and by Chi-Square test for the comparison.

Results

Forty patients undergoing fusion of fifty five curves compose two groups of this study. The patients were followed for an average time of 34.7 months (range 24 - 54 months). Gender, age, and the time of follow up distributions in the groups are shown in table 1.

The average preoperative, initial postoperative, the final follow-up curves and average loss of correction in the groups are shown in table 2. Table 3 depicts the mean numbers of operated levels and the state of the fusion.

In comparing the groups, there are no significant differences from the point of age, duration of following up, the number of operated levels and state of the fusion (P>0.05).

Statistically, also there is no significant relationship between the number of operated levels and the fusion rate in our patients.

Table 1. Gender and age distribution in operated groups

	Male/Female	Mean Age (year)	Mean follow up period (months)
Group 1	2/18	17.4 (+/- 1.5)*	36 (+/- 7.7)
Group 2	0/20	16.8 (+/- 1.8)	33.5 (+/- 6.3)

* Standard deviations are given in brackets

Complications were few. No significant neurologic or intraoperative/postoperative systemic complications were found in either group. All the patients with indeterminate fusions were asymptomatic. There are no cases of definite pseudoarthrosis in either group.

No problem in wound healing was found in the synthetic group. In the iliac graft group, one patient in group 2 had an acute postoperative infection in the instrumented area, which resolved with antibiotics, irrigation, and debridement. There were no late infections. Hardware failure (hook dislodgement) occurred only in one patient belonging to the synthetic group. The patient had solid fusion across the area of instrumentation. There was no rod breakage.

Table 2. Curve magnitude in pre- and postoperation

	Group 1 (iliac crest bone graft)		Group 2 (bioactive)	
	Degree	Percentage	Degree	Percentage
Average pre-op curve	60	-	63.8	-
Initial post-op curve	24.2	59.7	25.8	59.6
Final post-op curve	27.4	54.3	28.4	55.5
Loss of correction	3.2	5.4	2.6	4.1

Table 3. operated levels number and final fusion assessment

	Group 1 (iliac crest bone graft)	Group 2 (bioactive)
Average number of operated levels	9.5 (+/-1.5)*	10.2 (+/- 1.3)
Final fusion assessment	3cases(15%);Indeterminate Others; solid	2 cases (10%); indeterminate Others; solid

*Standard deviations are given in brackets

Discussions

This study was carried out to determine if the bioactive glasses compared favorably with established fusion rates using autograft. We had 12.5% indeterminate fusions (with no definite pseudoarthrosis) while pseudoarthrosis rate of Lenke et al (21) with CD instrumentation was 1% and that of Richards (22) 2% with TSRH instrumentation, both using iliac crest bone graft.

Our average loss of correction in group 1 was 5.4% and in group 2, 4.1%. There were superior to other quoted studies in the literature using autograft, which ranged from 7% to 14% (21-23).

The potential advantages of using iliac crest autograft, which is a good quantity and quality of bone, must be weighed against the potential disadvantage. Documented donor site complications include pain, hematoma, seroma, false aneurysm, blood loss, fracture of the iliac wing, visceral and ureteral injuries, peritoneal perforation, infection, sacroiliac instability, healing problems, neurovascular injuries and growth disturbance in children (1, 24-27).

To prevent such complications and to avoid the use of allograft, some authors reported their experience with biomaterials, such as synthetic porous ceramic (12, 28) with satisfactory results.

Successful outcomes have been reported with use of ceramics in surgery for AIS. A prospective randomized study of 341 patients undergoing posterior fusion for idiopathic scoliosis compared autograft with macroporous biphasic calcium phosphate blocks and found no significant difference in fusion rates 18 months after surgery (28).

Charles (29) compared three different bone grafting techniques (group A: autologous iliac crest bone graft, group B: freeze-dried corticocancellous allograft, and group C: composite graft of autologous bone marrow and demineralized bone matrix) in 88 consecutive patients and concluded fusion rate were comparable for group A and group C and better than group B. They noted that the composite graft is their preferred graft for fusion in AIS.

A recently report by Gosain (30) examined the safety and efficacy of bioactive glass for craniofacial reconstructions. This literature review supported various clinical applications of bioactive glasses. The article suggested using bioactive glasses in particulate form, preferably mixed with 10% to 20% autogenous bone particles.

Although, the supplementations of the construct with autogenous iliac crest bone graft, allograft, or various

types of bone graft substitutes are attractive, the fusion technique is probably the key of a perfect posterior arthrodesis. As Philippe and coauthors (31) showed, local bone graft alone, when performed with meticulous basic fusion technique, could render satisfactory results in adolescent idiopathic scoliosis surgery.

Although, we accept that the number of our cases is not enough, the results of this study could suggest that spinal fusion using the bioactive glass gives similar results when compared with autogenous iliac crest bone graft. Obviously, the former method avoid vast majority of complications associated with harvesting autogenous iliac crest bone graft.

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