Clinical, Radiographic, and Histologic Comparison of Ridge Augmentation with Bioactive Glass Alone and in Combination with Autogenous Bone Graft.

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ABSTRACT

Introduction: In spite of multiple applications of bioactive glasses, these materials have not been evaluated yet for ridge augmentation. Due to the large number of patients who need ridge augmentation and the benefits of Nova Bone, in comparison with other alloplasts, this study was fulfilled for evaluation of Nova Bone ability in ridge augmentation.

Methods: The samples of this experimental study are four dogs. In each one, two months after extraction of lower premolors and alveolectomy of that area, one side was augmented with NovaBone alone and the other side was augmented with the combination of Nova Bone and autogenous bone. After 2,4, and 6months, changes in ridge height were evaluated with clinical and radiologic methods. In the end of study, the dogs were sacrificed for obtaining histologic samples.

Results: In the alone NovaBone group, grafts of two ridges were exposed, but in the other two ridges, in spite of insignificance of statistic test, the amounts of ridges augmentation were clinically significant (mean: 6.5 mm) and new tissue, containing bony texture, was formed. In the other three ridges, in addition to significance of statistic test and formation of new tissue containing bony texture, the amount of ridge augmentation was considerable(mean: 5.5 mm). There wasn't significant difference between two forms of Nova Bone usage.

Discussion: Without considering of the results of statistic tests, the amounts of ridge augmentations were clinically significant in both groups. Therefore, considering the radiologic and histologic findings, and the biocompatibility of NovaBone, both forms of this material can be successful in ridge augmentation.

Key Words: Ridge augmentation, Bioactive glass

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Introduction

After extraction of teeth, a progressive recession of alveolar ridge will occure [1]. After 2 to 3 years 40-60% of ridge height reduces, and then the recession will continue by the rate of 0.5-25% per year to the end of the life [2]. This recession plus production of many problems will reduce retention and stability of complete dentures [3] and then it can progress to a stage that make the denture useless, complete [4].

Ridge augmentation has been one of the most important subjects in pre prosthetic surgeries. Although, need to these surgeries are reduced, because of osseointegrate implants, but in many circumstances many patients can not use implants and also: in some instances for insertion of implant, it needs ridge augmentation [5-7]. There are many procedures for ridge augmentation but the most common procedure is using alloplastic materials in the form of alone graft on the ridge crest. Of course, the alloplastic material is useful for ridge

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augmentation which can adhere to bone, otherwise it will be threatened by displacement, sliping, infection, and extrusion [8]. Hydroxyapatite is appraprate because of its osteoconduction property that can adhere to bone [9] therefore it has the most use in ridge augmentation.

In 1971, Professor Hench and his coworkers presented a new glass formulation that had more osteo conduction activity in comparison with hydroxyapatite. They named that material Bioglass [10].

Nowadays, it has been proved that bioactive glasses not only can adhere to surrounding bone [11] but also can remodel to normal bone by passing the time [12]. These materials can adhere to soft tissues other than bone [13-15]. Also the hydrophility can be help ful in hemostasis.

Although bioactive glass has been used in many subjects [16-23] but there is not any study on its capability in ridge augmentation. In this respect, this study has done on capability of these materials in ridge augmentation. Bioactive glass used in this study was novabone (45S5 bioglass) with particle size of 90-110 micrometer.

Materials and Methods

This experimental study was done on four dogs (Three male and one female) from mixed Iranian races. Before initiation of each surgical process, the dog became unconscious by injection of ketamine, 2 mg/kg, Iv, and Rampone, 1.1mg/kg, Iv. Also the site of surgery was locally anesthetized by infiltration injection of lidocaine %2 with 1/100000 epinephrine. For Infection prevention, in each surgical process prophylactic procaine penicilline and dihydrostreptomycine were injected and continued after surgery for five days with the same antibiotics.

First surgical process: Similarization of recessed alveolar ridge

After triangular flap elevation from the distal of canine tooth to mid buccal of lower carnassial tooth, the crowns of second to fourth premolar teeth were cut in vertical form then cortical bone was removed to the region of premolar apexes, and the premolar teeth were extracted.

In lingual region, after envelope flap elevation, alveolar bone was removed completely to the region of apical sockets (figure 1). At the end, inter dental papilla were incised and the site of incision was sutured in horizontal mattress form by the 3-0 chromic suture.

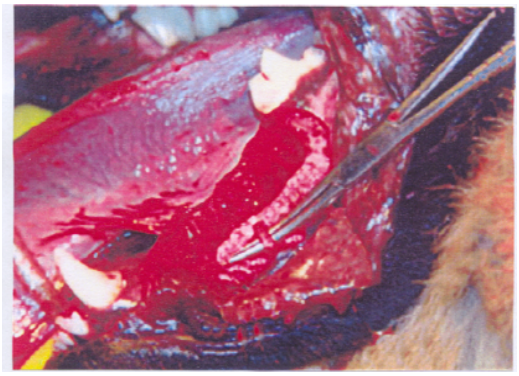

Figure 1: View of dog's jaw after radical alveolectomy.

Second Surgical process: ridge augmentation

Three months after first Surgery, premolar regions of lower jaw were well repaired in all instances and were transformed to alveolar ridge (figure 2). Then, second surgical process began, but one week before the surgery by pre formed partial trays, molding of both sites of alveolar ridge was performed in each dog by alginate and cast preparation was done. Wax up was done for ridge augmentation, with the use of red wax and acrylic splints were designed on it.

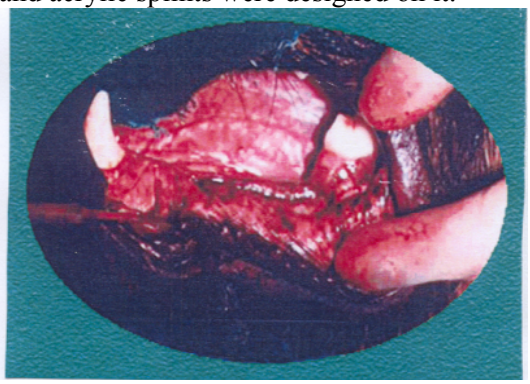

Figure 2: Alveolar ridge

Second surgical process was done at the same time in two regions: the mouths and the feet of the dogs. In the mouth, by using a vertical incision in distal of canine, a sub periostal tunnel was produced on the ridge, which terminated distally with a distance of 1 to 2 milimeters from lower carnassial tooth. In the foot bone, a graft was removed from tibial tuberosity which then broken to pieces. Bone grafts were spongy bone in three cases and was cortical bone only in one case, because in that case, we didn't have success for spongy bone removal, after opening the donor site (using cortical bone together with NovaBone had already been reported [24]).

For reducing interacting effects, the compound of novabone (in ratio of 1:1) from the region beside distal upper premolar was inserted in one side of each dog's jaw and in other side of that dog's jaw, pure novabone was inserted (split mouth design). After suturing the incisions by 3-0 chromic suture, acrylic splint was inserted on the ridge and was fixated in its site by circummandibular wiring (figure 3). For two weeks, the animals were fed by soft diet food of calcium complement. After surgical period, no sign of wound dehiscence or infection was noticed in animals' feet and mouths.

To measure the changes in ridges after augmentation, clinical and radiologic devices were used with time intervals of two, four, and six months.

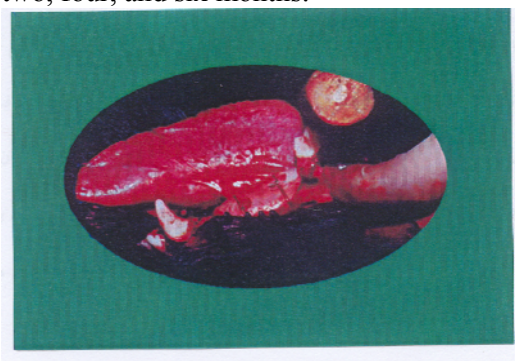

Figure 3: Support of augmented ridge with the use of acrylic splint

Clinical measurments

At the beginning of second step and before the start of surgery, the teeth were inserted in centric occlusive situation and the distance between the cusps of first to third upper premolars and lower alveolar ridge was measured by a ruler (figure 4). The mean of the distances between second and third premolars was considered as distance between upper premolars and lower ridge of that side. In each dog, this amount (space between cusps of upper premolars and the ridge) was measured after augmentation in intervals of 2, 4, and 6 months in both sides of the jaw. In each ridge, the amount of ridge height increase after augmentation was the difference of upper measurements in two months interval.

Because upper and lower premolar teeth of the dogs have no connection with each other in the natural form and there are spaces between them, so after alveolectomy in the region of lower premolars there is no probability for over eruption of upper premolars. Since the material insertion had begun from distal side of upper first premolar, distance between upper first premolar and the ridge, was considered only for accuracy of measurements in multiple time intervals.

Radiologic measurement

At the beginning of second process and before the start of surgery, control radiographies were taken from alveolar ridge, and also immediately after augmentation (before acrylic splint insertion), and the most

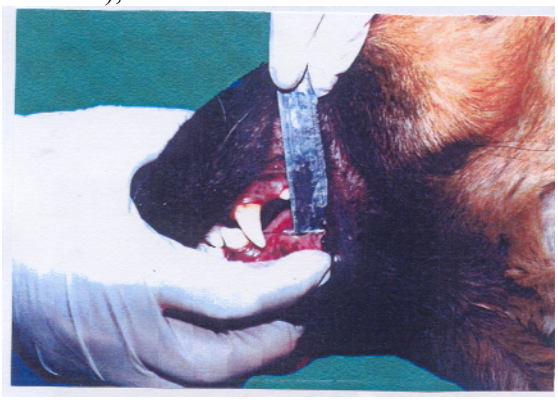

Figure 4: Method of clinical measurement

height of material was measured. Then radiographies were taken form the ridge and the most measured height of their material in time intervals of 2, 4, and 6 months after augmentation.

A metalic ball with distinc diameter was inserted on the film for omission of magnification effect probability.

Third phase surgery: Preparation of histologic specimen

Six months after ridge augmentation, the dogs were sacrificed by the way of vital perfusion and the alveolar ridges of each dog were removed and they were put in the buffered formalin.

Finally each ridge was divided into 3 pieces with Anterior Segment was in front of upper first premolar, Middle segment was in front of upper second premolar and posterior segment was in front of upper 3rd premolar. Each of them was placed in a separate container with a proper code buffered in formalin and sent as a histologic specimen.

The anterior segment was used as a histologic control in the lab. First, the specimen was decalcified and it was continued until hard tissue density became equal to soft tissue.

In this stage, 3 slides were prepared from the middle and the end of each segment. The slides have been histologically evaluated at first by a general pathologist and then by an oral and maxillofacial pathologist by one way blind method.

Results

Research Findings

In 2 ridges augmented with Nova Bone alone the grafts were exposed. The results of clinical and radiographic measurement showed that the entire graft had been lost; because the ridge height in clinical measurement were 0 mm and 0.5 mm in the second month and in the next months was o (Table 1).

At the radiography which was prepared from these 2 ridges the ridge height at second month and after that was o (Table 1). So the 0.5 mm ridge height in the second month could be due to inflammation.

But in the other 2 ridges the graft have not been exposed. The difference between clinical ridge heights in second month after augmentation was 7 mm and 7.5 mm and reached to 6.5 mm at the end of the sixth month.

In radiography the height of these 2 ridges were 6 and 6.5 mm immediately after augmentation and reached to 6 mm in the second month and the height was maintained till the end of the fourth month.

Table 1: Clinical and radiographic ridge height measurements after augmentation with Nova Bone alone (mm).

Ridge height	Case No	1	2	3	4	Mean	SD
Clinical							
	After 2 months	7.5	0.5	7	0	3.75	4.14
	After 4 months	7.5	0	7	0	3.63	4.19
	After 6 months	6.5	0	6.5	0	3.25	3.75
Radiographic							
	Immediately	6.5	5	6	6	5.88	0.62
	After 2 months	6	0	6	0	3	3.46
	After 4 months	6	0	6	0	3	3.46

On the sixth month radiography the density of the graft was similar to dog's mandible so the evaluation of materials height was not possible.

Histologic Evaluation

In two ridges in which the graft were exposed, there were no particles of Nova Bone or new tissue between periosteum and Bone of the dogs. But in the other two ridges, the Nova Bone particles were seen.

Most of the particles were surrounded by bone also some of the particles were surrounded by fibrotic tissue. Many of the particles were cracked and divided to smaller segments. At the center of some of the particles bony tissue was seen which was in relation to some substances and Bone tissue around particles.
The new Bone formation was in form of osteoid and trabecular form and the osteiod type was dominant, compared with trabecular form (Figure 5).

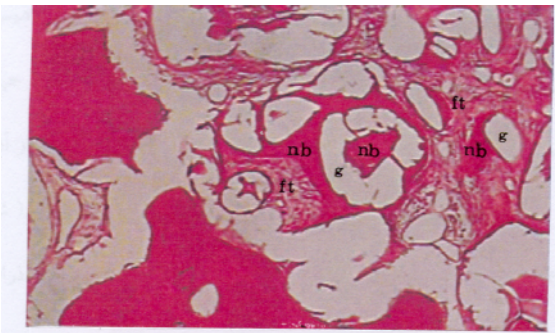

Figure.5: Microscopic view of new tissue nb: New Bone, g: bioactive glass particles, ft: fibrotic tissue.

The fibrotic tissues which were seen in some places are islands with a lot of vascular tissue and the number of giant cells was minimal.
In two histologic specimens the Nova Bone particles were completely in connective tissue (unwanted) and there was no contact between them and the bone. But in their microscopic views bone tissue formation was seen but their quantity was developed than when these particles were in contact with bone (Figure 6).

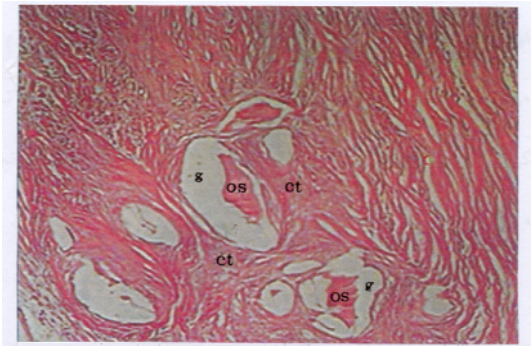

Figure 6: Microscopic view of bioactive glass particles in soft tissue.
ob: New osteoid Bone, G: Bioactive glass particles, ft : New fibrotic tissue, Ct: Connective tissue hostes.

In one of the ridges which were Augmented by spongy bone and NovaBone, The graft was exposed.
The results of clinical and radiographic measurement (Table 2) showed that in the ridges in which the grafts were exposed the heights were not totally lost but they were approximately half of the heights produced at the second month at radiography after ridge augmentation, and maintained till end of the fourth month.
But in other 3 ridges, after six months, the height levels increased from 4.5 mm to 6.5 mm in clinical measurement and 4 to 6 mm in radiographic measurement at the sixth month's radiography. The density of the graft was similar to dog's mandibular bone so the evaluation of the material's height in radiography was not possible.

Histologic evaluation

In all ridges, even in the case which the graft was exposed, Nova Bone particles were seen between periosteum and Bone of the Animal. The Microscopic view of the specimens in this group of ridges were similar to the previous group.

Table 2: Clinical and Radiographic ridge height Measurements, after ridge augmentation by combination of Nova Bone and Autogenic Bone

Ridge height (mm)	Case No	1	2	3	4	Mean	SD
Clinical							
	After 2 months	6.5	3	6.5	5.5	5.3	1.65
	After 4 months	6.5	2.5	6.5	5.5	5.25	1.89
	After 6 months	6.5	2	5.5	4.5	4.63	1.93
Radiographic							
	Immediately	6	5	5	5	5.25	0.5
	After 2 months	6	2.5	4.5	4	4.25	1.44
	After 4 months	6	2	4.5	4	4.13	1.65

Discusion

The bioactive glasses have been used in several cases. But no study have been published yet in which they have been used for ridge reconstruction. So this study was arranged by the aim of evaluating the ability of NovaBone for ridge augmentation.

Because of importance of graft fixation for ridge augmentation [25-27] in this study we used an acrylic splint for graft support for two months. Although the acrylic splints supported the graft adequately but also there was a factor for plaque and food retention. After two months the retention of plaque and food over the splints were significantly noticeable.

After the splints have been removed in all ridges the sign of inflammation was visible. Also
the graft have been exposed in three ridges.

The biocompatibility of bioactive glasses have been proved so far in several studies [28-31].

The exposure of Nova Bone could be due to poor oral hygiene of the dog's mouth (due to acrylic splint) or due to pressure produced at the time of placement of excess material during ridge augmentation.

Because the soft tissue over the ridge is stiffer and more adhesive than usual, due to radical alveolectomy (after slowly resorption of the ridge) but in 5 ridges that the grafts were not exposed, increasing the ridge heights were significant after 6 months from clinical standpoint.

Actually the mean of height increase at 2 ridges which had been augmented by Nova Bone alone, was 6.5 mm, and in 3 ridges which had been augmented by combination of NovaBone and Autogenic Bone, was 5.5 mm.

Histologic evaluation showed that in all ridges which the grafts had been remained after 6 months the new bone tissue was formed.

Nova Bone particles over the ridge were similar to the changes produced in these particles in schepers and Duchyene study [32].

In the other words, similar to changes of these substances in bone defects, these findings showed that although the Nova Bone particles over the ridge are in contact with bone only in one direction and are surrounded by soft tissue from 3 other direction but the Bone changes take place in all directions.

Tadjoedin et al [33] and Cordioli et al [34] also used bioactive glass for augmentation of maxillary sinus floor and observed that in particles close to the sinus floor membrane bone tissue was formed.

Although in our study the quantity of bone tissue produced in particles close to the soft tissue was not compared to particles close to dogs' bone, but histomorphometric assessments in studies by Tadjoedin et al and Cordioli et al proved that fewer bone tissue was produced next to soft tissue.

Schepers and Duchyene study proved that the new tissue consisted of bioactive live glass bone and fibrotic tissue, after 2 years. The new tissue over the ridge finally consisted of all 3 tissues.

So it can be expected that when an ugmented ridge with NovaBone is functioning below a complete dentnre, unlike a grafted bone, will not resorb (because of glass particles and fibrotic tissue), and in other hand, due to pressure of bone, and fibrotic, and vascular tissues, there is always a possibility of insertion of an implant over that (unlike Hydroxyapatite).

In this research we came to an interesting finding and that was formation of bone tissue in Novabone particles arranged in soft tissue.

Yuan et al also reported this ability of bioactive live glass for the first time [35].

The results of this research shows that Nova Bone can be used for increasing ridge height both alone and in combination with autogenic bone.

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