

Radiological study of using bioactive glass and acacia gum in repairing segmental radius bone defects in rabbits

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Abstract

The current work aims to assess the effectiveness of bioactive glass mixed with acacia gum implants for the treatment of radial bone defects in rabbits. Under general anesthesia, an osteotomy was performed at the distal shaft of the radius for inducing a segmental bone defect in the rabbit model. The experiment randomly allocated into two equal groups of 15 each. Firstly, in the control group, a 10-mm section of the distal shaft of the left radius bone was without treatment. The second group, the treated group, had the defect filled with a bioactive glass mix and acacia gum at the defective site. The clinical investigation demonstrated no signs of immunological reaction or any inflammatory signs. Radiographic examination evaluate the stability of the bioactive glasses along the period of study, and it integrates with the ends of bone fractures with less periosteal reaction in addition to a gradual reduction in the defect site and density of the bioactive glass implant edge due to the degradation of crystalline particles that reveals both osteoconductive and osteogenic properties that appear in the treated group rather than in the control group that submitted non-healing due to the critical size and the bone characteristic by synostosis or cross-union between the radius and ulna. Also, the presence of acacia gum showing adhesive and mechanical strength to bioactive glass reveals superior performance in bone remodeling and ensures structural stability. It is therefore appropriate for bone tissue engineering applications. In conclusion, bioactive glass is a promising material for segmental bone defect repair, offering a biocompatible and effective alternative to traditional grafts, and no adverse effect was recorded in the study.

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Introduction

Bone defects or fractures, is a disruption in the continuity in the integrity bone structural which characterized by either partial or complete agreement that pose significant challenges in veterinary orthopedics due to their limited capacity for natural healing and defects often lead to delayed or non-union, particularly in long bones like the radius (1,2). At the same time, recent progress in tissue technology for bone regeneration has proven to be very effective, as explained by successful results in different animal models,

including dogs, cats and horses (3). In addition, the discovery of artificial bone alternatives, such as bone cells, osteogeneous factors, osteoclasts and biomaterials, revealed them as a viable alternative because of their immune system compatibility (4). In particular, bone transplant materials can occur from natural sources such as autograph, allograph or xenograft, or biochemically synthesized (5-7). In particular, xenogeneic bone alternatives such as the xeno-bovine implantation achieved from the calf ulna have been used as a space filler for the treatment of defects in rabbits (8). Several studies also have investigated different approaches

to enhance bone and soft tissue healing in rabbits, including stainless steel rods for fracture fixation (9), small intestine submucosa and bovine pericardium grafts (10,11), low-level laser therapy (12,13), platelet-rich fibrin with silver nanoparticles (14). In addition, synthetic materials such as bioactive glass implants 45S5 quickly link a hydroxyapatite layer on the surface with bone tissue in vivo, including the dissolution of the cations from the material, leading to an elevated pH of the surrounding matrix, which is in a silica-layer and later Ca-P within a few days, the soluble silica releases a significant amount of calcium and phosphorus, integrated into the developing bone matrix and helps with the formation of new bone tissue (15).

In particular, biometry such as bioactive glass, glass ceramics and calcium phosphate has been studied widely for its osteopathic applications under physical conditions due to the ability to stimulate hydroxyapatites (16). Various methods for correcting segmental long-bone deformities have also been the subject of numerous studies. There are remarkable studies conducted by Malik and Eesa, who found magnesium oxide nanoparticles, whether it was administered locally or systematically in combination with hydroxyapatites, and intensified the healing process in the distal radial fracture (17). Similarly, Atiyah and Al-Falahi noticed that egg-shell hydroxyapatites demonstrated excellent instability with the host and showed the minimum deterioration, especially when used in fabrication of large transplants (18,19). Another study of Mahdi and Rija using fish swim bladder in radius gap indicates that FSB improve bone regeneration in rabbits (20), especially when combined with autologous BMA coagulates. In addition, Eesa and other role as omental transplant emphasized in starting the rebuilding phase by reducing the callus formation (21), while Zebon and Eesa demonstrated the better regenerative ability of nano and microcrab shell scaffolding, in repairing tibial segmental defects (22). Another study of Garcia highlights the capacity of bioactive glass scaffolding to increase bone treatment and suggests that they can serve as a viable alternative for autograph in orthopedic surgery (23).

In addition, Acacia or Arabic gums include a natural biopolymer and a complex mixture of glycoprotein, obtained from the exudate of acacia trees, is recognized for non-toxicity, an essential feature of food, medical and biomedical fields. Recent studies have focused on developing acacia glue-based nano composites, which have shown promising consequences in terms of mechanical strength and biodiversity for regeneration applications for bone tissue (24). Acacia Gum has been shown to increase the general performance of biometrics in the gum matrix, which provides it suitable for different biomedical applications (25). Bioactive glass is known for its excellent bioactivity, but naturally brittle and suffering from low mechanical strength, which limits the use of use in load-bearing applications (26). To remove these boundaries, we propose

the inclusion of the Acacia gum a natural, biocompatible and biodegradable, and provides a promising solution. Acacia Gum has unique properties such as excellent water solubility, strong glue skills and filmmaking ability, making it an effective binder and stabilizer (24). When integrated with bioactive glass, acacia gum enhances the cohesion between glass particles, promoting a more uniform stress distribution and reducing the risk of crack propagation (27). Its natural lime properties contribute to a more consistent general structure, leading to general cruelty and mechanical integrity (28). This synergy not only addresses the inner brushing of bioactive glass, but also preserves its bioactive properties. Ultimately, the general composite converted into a strong material suitable for advanced biomedical applications, which combine increased mechanical strength with biocompatibility (29). Consequently, this experimental study was conducted to evaluate the efficacy of bioactive glass incorporation with acacia gum materials in reconstruction of the Segmental Radius Bone Defects in Rabbits.

Materials and methods

Ethical approval

All surgeries that utilized in our study conventional ethical approval from the resident committee of animal care and use in the College of Veterinary Medicine-University of Baghdad (No: P.G/315, February 6th, 2025).

Experimental animals

Thirty healthy adult male rabbits weighing (1.5-2.5 kg) were recruited for this study. All animals were clinically examined by physiological examination before the start of the experiments and left for two weeks to acclimatize to the experimental conditions. Animals accommodated in the animal house of Baghdad University Veterinary College.

Experimental design

The 30 experimental animals were divided equal group fifteen of each; all the animals were induced 10mm segmental defects in distal-shaft of left radius bone. The defects were left empty in the control group and the defect filled with bioactive glass\acacia gum implant in the treated group. The defects in control and treated group were assessed radiologically at 0, 2, 4, 6, 8 weeks and 12 weeks post-operation to evaluate the development of newly formation of bone and complete bridging of the defect site.

Fabrication of bioactive glass

The bioactive crystals were proceeded in the laboratory of the College of Sciences of Baghdad University. Classic bioactive glass was prepared based on silicate network along with other oxides such as calcium oxide (CaO), phosphorus pentoxide (P₂O₅) and sodium oxide (Na₂O) which is the most widely researched known as 45S5 Bioglass® and composed

of 45SiO₂-24.5Na₂O-24.5CaO-6P₂O₅ in weight percentages (wt.%) consistent with the formulation used by (30) (Table 1), that is reported as successfully used as bone filler in clinical treatment of periodontal diseases and in middle ear surgery (31,32).

Table 1: Ingredients (wt%) and amount of powder (in grams) required for a 100 g batch of BG

Name	Composition (wt%)	Quantity powders (g)
Silicon dioxide (SiO ₂)	45.00	45.00
Sodium carbonate (Na ₂ CO ₃)	24.50	41.87
Calcium carbonate (CaCO ₃)	24.50	43.70
Phosphorus pentoxide (P ₂ O ₅)	6.00	9.72

Briefly, measuring the materials weight with sensitive balance the total batch weight may appears higher because raw carbonates decompose during melting and release CO₂ gas; therefore, extra weight is required to yield exactly 100 g of final glass oxides (33), then in mortar and pestle were milled for 30 minutes (Figure 1.A), which gives fine powder for grinding reagent mixture accepts graphite crucible and melts at 1200°C by electric melting furnace for 1 hr. (34) (Figure 1.B). The condensate shall be stirred repeatedly during drying to obtain homogeneous mixture, then subsequently cooled rapidly to room temperature to obtain homogenous bioactive 20% w/v crystal powder after that

preparation of Arabic gum 20 g of acacia powder (local market Iraq) in distilled water (parafilm-covered glassware) in 100 mL of the beaker mixed with a magnetic stirrer (Thermo-Scientific®) at room temperature according to the method described by (35) (Figure 1.C). Then, samples were resolved with the resulting solution to prepare a 5%, w/v acacia solution. Finally, mix the bioactive 20% w/v crystal powder with 5% w/v of acacia solution and ground in a mortar and pestle to form a paste-like substance and then poured into stainless steel molds and pressed using a handheld hydraulic compaction machine for 10 minutes (Figure 1.D) then take the implant out and dry it by oven in 150°C to form bioactive glass implants (Figure 1.E), then use a sterilization bag to sterilize the implant with UV disinfectants (13,36). The BG implant structure was then investigated by contrast analysis using (SEM: Scanning electron microscopy) and (XRD: X-ray diffraction).

Scanning electron microscopy (SEM)

The implant was analyzed by scanning electron microscopy (Axia-chemi-SEM \Thermo-scientific®), at (Al-khara for general trading for nanotechnology analysis). The size of the samples used in SEM was (3mm*3mm*10mm). Dried samples were wrapped in aluminum SEM sample mounts (Electron Microscopy Sciences) and sputter coated with gold using a sputter coater (Quorum/ Q150 RES) prior to testing. Finally, the samples were examined at 5,000 and 10,000 µm magnifications.

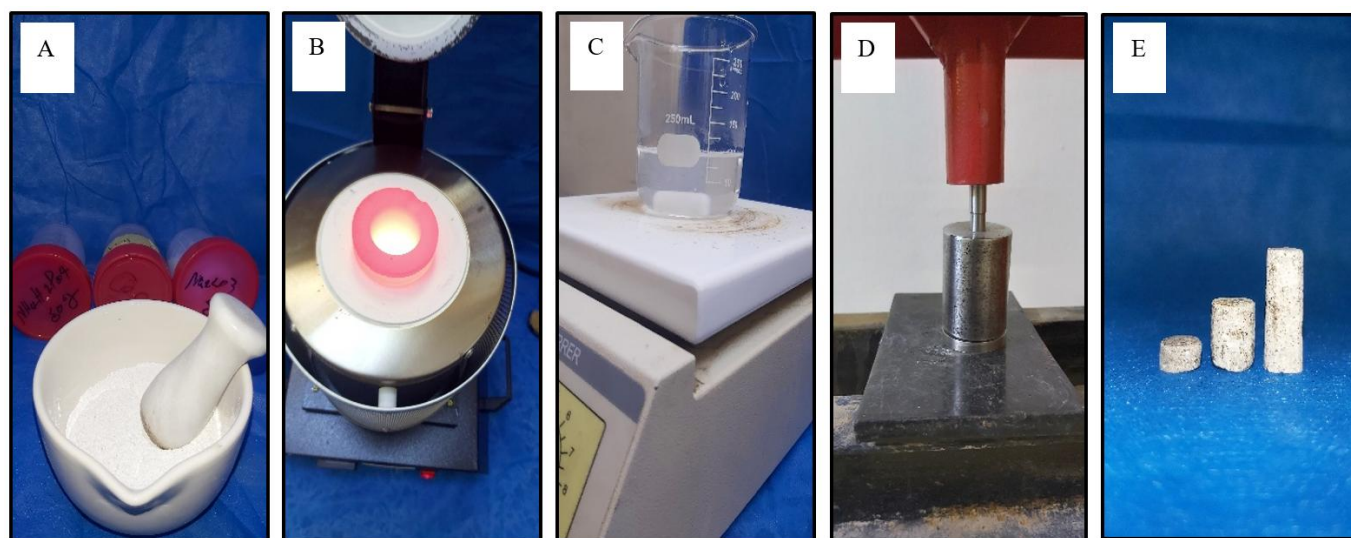


Figure 1: Photographs show the steps to fabrication of bioactive glass. (A) Grind and mix the materials by mortar and pestle. (B) The powder poured in graphite crucible and melted using high-temperature furnace at 1200C for 1 hr. (C) dissolved acacia powder with DW to prepare Arabic gum (D) pressed the mixture with handheld hydraulic compaction machine (E) bioactive glass implants multiple size.

X-ray diffraction analysis

The XRD analysis of bioactive glass was done using diffractometer (Aeris research edition XRD\ Panalytical®). The diffraction analysis was achieved with Cu as radiation source, 40 Kv high voltages, 30 mA current and scan speed 5/ min, to obtain structural information on an atomic scale from materials. The diffraction patterns were obtained in the 2 θ ° range from (20° - 70°).

Surgical procedure

Anesthetic protocol

A general anesthesia was induced by intramuscular combination of 40 mg/kg of 10% Ketamine (Alfasan-Holland) and 5 mg/kg of 2% Xylazine Hydrochloride (VMD-Belgium) according to (20,37-39).

Surgical operation

All operations were performed under aseptic technique, the left forelimb of the rabbit is prepared for surgery by positioning the animal in lateral recumbency then shaved, disinfected with antiseptic solutions then covered with sterile

drapes. The skin incision was approximately 3-5 cm of skin incision at cranio-medial aspect; The left radial flexor carpi-radialis and extensor carpi-radial-longus was blunt separated and exposed, firstly locating the radial bone defect and marking the site of osteotomy (Figure 2A), then 10-mm section of the distal radius bone was osteotomized using an oscillating electrical saw equipped with a fine circular blade (0.8mm thickness, 3cm diameter) and the osteotomized site was rinsed with 0.9% saline (Figure 2B) then the bioactive glass/acacia gum was press-fitted directly to the defect, tolerating intimate contact with the ends of bone without need any additional fixation (Figure 2C), the same procedure of osteotomized was repeated with control group except that the bone defect left untreated. Finally, the muscle and skin layer were closed with 3/0 Polydixenon (PDS) continuous suture material to provides prolonged tensile strength, offering sufficient support for both the muscle and the implanted material, and the skin incision was closed with 4/0 Polyglycolic Acid (vicryl) by subcuticular suture technique (Figure 2D).

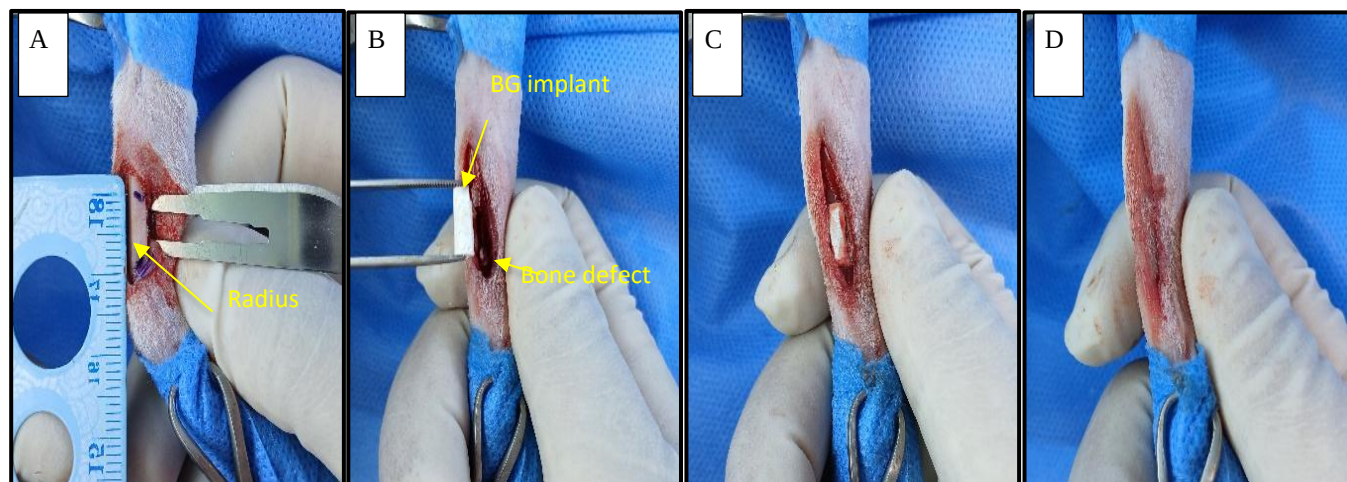


Figure 2: Photographs show the BG implanted in rabbit radius defect. (A) Marking the bone defect (B) 10-mm radial segmental defect in distal shaft of radius and the BG implant (C) The defect filled with BG implanted, (D) The skin closed by subcuticular suture technique.

Postoperative care

Securing the surgical limb with wrapping a gauze and supporting with insulin syringe then adhesive tape to supporting the area and prevent the animal from biting the surgical site for one week. The incision was monitored every 48hrs. for signs of inflammation, infection, or complications. To prevent infection, a course of antibiotics was administered (Ceftiofur sodium 40mg/kg S.C once a day for three days (Anova®) (40), and pain management was provided using analgesics (Meloxicam 1.5mg/kg S.C. once a day for three days (Anova®) (41).

Radiographic examination

For all animals tested, radiographs of the affected limb were taken in medio-lateral as the surgical limb is viewed immediately after surgery and 2week, 4week, 6week, 8week and 12week postoperative under exposure factors of kVP 45, MA 100, mAs 5.00 (Eco Ray x-ray machine Korean®).

Statistical analysis

Radiological scoring data (reduction in defect size, radiographic density, and remodeling of bone) (Table 2)

were subjected to two-way analysis of variance (ANOVA) using the Standard Least Squares procedure of JMP Pro 16.0.0 software (SAS, Institute Inc., Cary, NC, USA). The model included the fixed factors Treatment (Control and Treated), Week post-operation (W2, W4, W6, W8, and W12), and their interaction (Treatment $\times$ Week). Significant main effects and interaction means were identified at $P \leq 0.05$ using the post-hoc test Least Significant Difference (LSD).

Table 2: Modified Radiological scoring system of the Fracture Healing at 2nd, 4th, 6th, 8th and 12th weeks in all groups (42,43)

Description	Radiological scoring
Reduction in defect size	
Less than 25% reduction	1
25-50% reduction	2
50-75% reduction	3
More than 75% reduction	4
No gap	5
Radiographic density	
No density	0
Slight	1
Moderate	2
Dense	3
Remodeling of bone	
No remodeling	0
Less than 25% reduction in size of callus	1
25-50% reduction in size of callus	2
50-70% reduction in size of callus	3
More than 75% reduction in size of callus and canalization of marrow cavity	4

Results

Scanning Electron Microscope (SEM)

The SEM analysis of the bioactive glass/acacia gum implant showed a highly interconnected, well-distributed porous network, with porosity of the range of about 10 to 90mm, and indicated a wide range of pore size distribution, and the broadening peak of porous in the SEM evidence of the high purity of the bioactive glass/acacia gum. SEM observations revealed the crystalline surfaces, where grains indicated the crystal structure in the material. The sample also showed high porosity and interconnected micron-pores. Together this morphological feature points that the material is a potential candidate to give support for cell infiltration and in bone tissue regeneration process because of the interconnected porosity and pore dimensions (Figure 3).

X- ray Diffraction (XRD)

The XRD analysis of bioactive glass was conducted matching its pattern with the reference data of the International Centre for Diffraction Data (ICDD, 2006). The indexed diffraction peaks are predominantly those of calcite and sodium-calcium silicate, according to JCPDS#33-0302 and PDF#05-0586 (standard diffraction database sheet) for sodium-calcium silicate and calcite respectively. The samples exhibited to be in the amorphous state with some crystalline phase. Clear diffraction peaks were generated at 2θ values of around 22.09° , 24.47° , 30.52° , 34.08° , 36.72° , 40.89° , 43.58° and 47.65° , which can mainly be assigned to composition of BG phases. Maximum intensities were low and medium counts, being evidence of partial crystalline material. The balanced nature of these structural features is desirable for bioactivity along with mechanical stability, giving a suggestion that the material might be useful for biomedical bone implant applications (Figure 4).

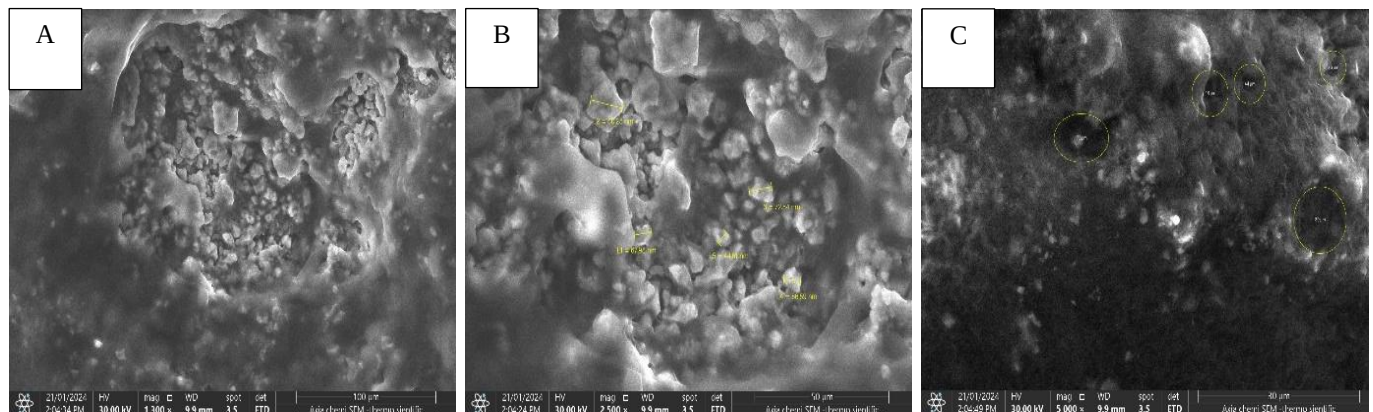


Figure 3: SEM shows (A), presence of surface crystals. (B) formation a surface of crystals with various particle size (C) a well-connected porous structure with pore sizes approximately 10 to 90µm.

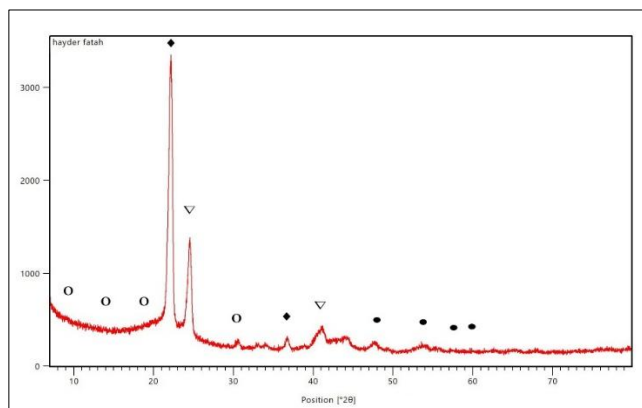


Figure 4: Shows several sharp peaks representing crystalline reflections mainly from calcite and sodium-calcium silicate phases, along with broad humps indicating the presence of an amorphous silico-phosphate glass matrix.

Clinical evaluation

Post-operatively, the animals were closely observed for any complications. There were no reported intolerances during the experimental period. A bandage was placed to stabilize and to avoid biting the operated limb by the animals. Wound healing progressively improved in all animals and the inflammatory signs decreased substantially within 1 week. These benefits were especially pronounced in the bioactive glass–acacia gum implant groups. Conversely the control group suffered early fracture of the operated limb postoperatively.

Radiological evaluation

A rabbit radius bone model was used in the present study to establish a critical-sized segmental defect according to the formula $(2n + 1)$, where n is the bone diameter, which is in the range of 3.02 ± 0.13 mm in radius bones. The defect was used to assess the efficacy of a bioactive glass–acacia gum composite implant for the regeneration of bone with and without treatment. In control group (Figure 5), radiographs obtained postoperatively confirmed that a segmental defect was created immediately after surgery (presence of a well-defined radiolucent gap with sharp bone edge and absence of any preoperative injury). At 2 weeks, the defect center was still radiolucent exhibiting no spontaneous bridging and mineralized tissue formation. At 4 weeks, there was minimal periosteal reaction and slight reduction of the defect gap suggesting restricted intrinsic healing, with the formation of a hazy low-density opacity representing immature tissue. At 6 week, partial closure of the defect with thick callus was clearly observed at the distal part with bone marrow cavity obliterated proximally and periosteal callus extending toward the gap center with no complete bridging. At 8 weeks, enhanced periosteal activity and an increase in radiopacity of the callus indicated mineralization limited progression, but the defect remained unbridged. At 12 weeks the defect remained with incomplete healing, but with significant periosteal new bone and with displaced callus extending from the distal radius to the ulna lead to pathological radio-ulnar synostosis, representing an unintended compensatory stabilization mechanism in the absence of defect repair.

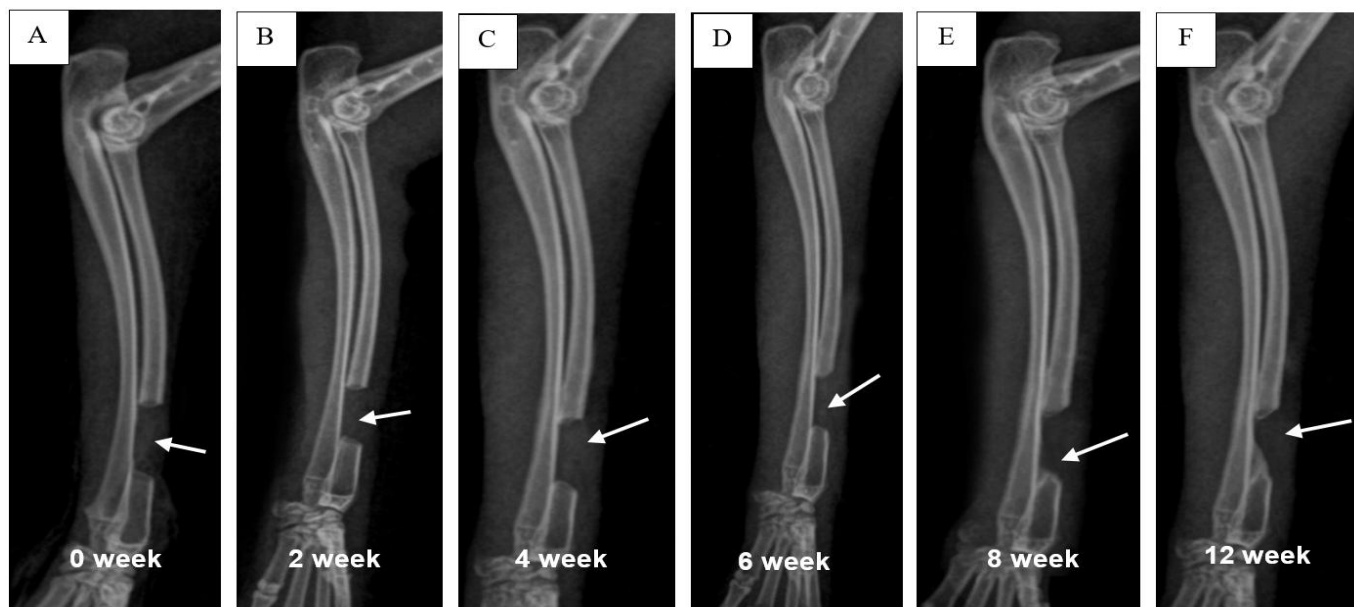


Figure 5: Radiograph of the 10mm control group after (A) 0-week (B) on 2 weeks, (C) on 4 weeks, (D) on 6 weeks, (E) on 8 weeks and (F) on 12 weeks.

In the treated group (Figure 6), the immediate post-operative radiographs showed that the bioactive glass/acacia gum composite filled the defect fully and was correctly placed, as indicated by a thin radiolucent line for the original interface. At 2 weeks, the implant was stable and distinct from host bone, establishing position integrity and creating a baseline for further integration analysis. At 4 weeks, disappearance of the radiolucent line showed initial integration of the implant, and mild reduction in radiodensity was indicative of progressive resorption of the bioactive glass. At 6 weeks, contiguous mild ulnar reaction was

interpreted as early osteoinductive and bone remodelling. At 8 weeks, continuous implant contact with bone edges and indistinct interface indicated the persistent of osteointegration and bone regeneration, and along with the ongoing implant degradation. At 12 weeks, the radiographs exhibited significant remodelling, decreased implant size and radiodensity, a decrease in the defect gap, and complete bridge with the newly formed bone. The implant allowed defect healing and bone regeneration without complications and demonstrated its osteoconductive and resorbable behaviour (Table 3, Figure 7).



Figure 6: Radiograph of the 10mm treated group after (A) 0-week (B) on 2 weeks, (C) on 4 weeks, (D) on 6 weeks, (E) on 8 weeks and (F) on 12 weeks.

Discussion

The SEM observation showed that the bioactive glass implant had pores between 10 and 90 μm , which could be favorable to cell attachment, migration, and subsequent tissue ingrowth especially in early healing stage is nutrition and cell infiltration for promoting osteogenesis, supported by (44). The existence of a well-interconnected porous structure is important for nutrient supply to neovascularization and implant integration with host (45). In addition, the crystallinity found in SEM analysis of the implant structure was to provide mechanical stability and ensure the bioactivity of the implant, which was essential in the bone scaffold performance (46). The noticeable resorption of glass particles observed toward the later stage of healing is

additional evidence of the implant's bioactivity as well as its successful integration with the new forming bone.

In the X-ray diffraction (XRD) analysis of the bioactive glass patterns of the samples showed an amorphous matrix together with crystalline phases. It is beneficial because the amorphous silico-phosphate glass matrix supports bioactivity and ion release while crystalline phases, mostly calcite and sodium-calcium-silicate strengthen mechanical properties (46). The crystalline particles are the small crystalline phases, these phases slowly dissolve through ions exchange to body fluid, which can release biomechanically active ions, such as calcium, sodium, phosphate and silicate (47). These degradation products are involved in forming a hydroxycarbonate apatite (HCA) layer on the implant surface, which is essential for osteoconduction and

osteogenesis. Thus, the crystalline degradation directly contributes to bone bonding and tissue regeneration (44,47). The wide profile of silica indicates the amorphous nature of the glass network, typical of a melt-derived bioactive glass composition that has the capability to exchange ions and also demonstrate bioactivity in physiological environment (48). This partial crystallinity is in good agreement with the melting-quenching synthesis, where controlled crystallization can improve mechanical properties without sacrificing bioactivity. The mechanical strength verified by

structural and morphology characterizations in SEM, which showed an interconnected porous network, and XRD, that confirmed partial crystallinity contributing to mechanical stability also the addition of acacia gum probably enhanced the adherence between bioactive glass particles, maintaining the mechanical strength and uniform stress distribution; which is agreement with previous studies (24,27). This mixed microstructure is important for the applications of implants for bone reconstruction and load transmission (49).

Table 3: Radiological scoring data; reduction in defect size, radiographic density, and remodeling of bone

Week post-operation	Treatment	Reduction	Density	Remodeling
W2	Control	1.00 ± 0.00 g	0.00 ± 0.00 e	0.00 ± 0.00 d
	Treated	2.00 ± 0.00 de	1.67 ± 0.33 bc	0.33 ± 0.33 d
W4	Control	1.00 ± 0.00 g	0.00 ± 0.00 e	0.00 ± 0.00 d
	Treated	3.00 ± 0.00 c	1.67 ± 0.33 bc	1.33 ± 0.33 c
W6	Control	1.33 ± 0.33 fg	0.67 ± 0.33 de	0.00 ± 0.00 d
	Treated	3.33 ± 0.33 c	2.33 ± 0.33 ab	2.00 ± 0.00 b
W8	Control	1.67 ± 0.33 ef	1.00 ± 0.00 cd	1.00 ± 0.00 c
	Treated	4.00 ± 0.00 b	2.67 ± 0.33 a	3.00 ± 0.00 a
W12	Control	2.33 ± 0.33 d	1.33 ± 0.33 cd	1.33 ± 0.33 c
	Treated	5.00 ± 0.00 a	2.67 ± 0.33 a	3.00 ± 0.00 a
Main Effect				
<i>Treatment</i>				
Control		1.47 ± 0.17 b	0.60 ± 0.16 b	0.47 ± 0.17 b
Treated		3.47 ± 0.27 a	2.20 ± 0.17 a	1.93 ± 0.28 a
<i>Week</i>				
W2		1.50 ± 0.22 d	0.83 ± 0.40 b	0.17 ± 0.17 c
W4		2.00 ± 0.45 c	0.83 ± 0.40 b	0.67 ± 0.33 b
W6		2.33 ± 0.49 c	1.50 ± 0.43 a	1.00 ± 0.45 b
W8		2.83 ± 0.54 b	1.83 ± 0.40 a	2.00 ± 0.45 a
W12		3.67 ± 0.61 a	2.00 ± 0.37 a	2.17 ± 0.40 a
<i>P-value (LSD)</i>				
Treatment		<0.001 (0.278)	0.001 (0.368)	<0.001 (0.241)
Week		<0.001 (0.440)	<0.001 (0.582)	<0.001 (0.381)
Treatment × Week		0.011 (0.662)	0.001 (0.823)	0.001 (0.539)

Values are means ± SEM. Means in a column without a common superscript letter differ ($P \leq 0.05$).

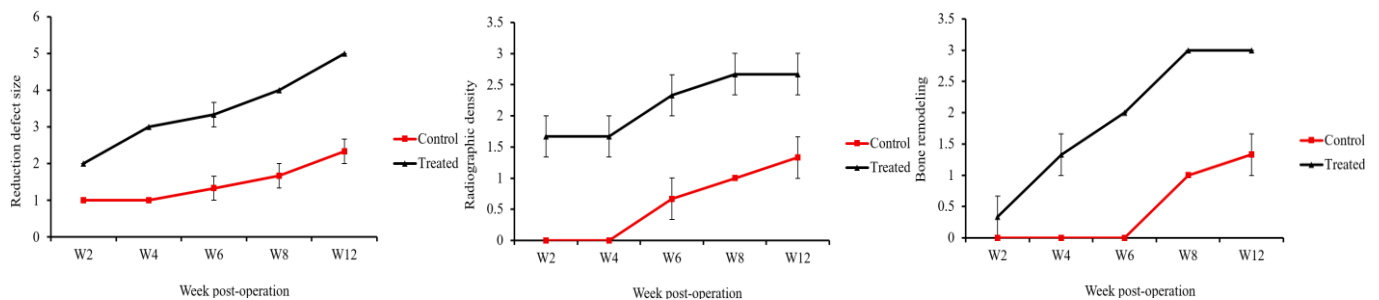


Figure 7: Radiological scoring data; reduction in defect size, radiographic density, and remodeling of bone.

In the clinical observation decreased levels of inflammation and fast wound closure are in line with (50) where full closure of wounds was observed within one week. The bioactive glass implants have been providing a suitable environment for promoting bone regeneration (23). By contrast, in the control group, showed fracture of the operated limb early in the postoperative period that what Minto demonstrated in the critical lesion study that an ulnar damage was appropriately noted (51). This highlights the failure of spontaneous healing in critical-size bone defects without external intervention.

On radiographs evaluation of the radius bone the control group gap was observed at least the end of the experimental period, thus no signs of spontaneous bridging. This is in accordance with previous studies demonstrating that large defects do not heal spontaneously due to the limited capacity of cortical bone to regenerate in segmental defects (52,53). The well-defined border and persistent radiolucency also fit the criteria for a critical-sized defect, according to several reports (54,55). The low periosteal reaction observed at four and six weeks in the control group indicates that relatively little endogenous attempt to stabilize the defect would be made through periosteal new bone formation (56). However, this reaction was insufficient to form bridging callus and resulted in pathological fusion between the adjacent bones radio-ulnar synostosis, as reported earlier (54,57). This inadvertent fusion due to absence of bridging between bone end and callus overgrowth, this phenomenon, attributed to compensatory stabilization, aligns with findings by (58) which reported similar adaptive mechanisms in untreated defects. whereas the treated group with bioactive glass–acacia gum implant produced radiographic evidence of ongoing osteointegration and controlled biodegradation. This finding observed at early as 4 weeks implant was beginning to integrate more effectively with the surrounding bone tissue this early sign of osteointegration and osteogenic processes (59). The decrease in density of implants weekly maintained the bioresorption knowledge, a favorable feature for being replaced by newly formed bone (60,61). The subtle ulnar periosteal reaction in the treatment group may have been related to local osteoinduction in the presence of implant material, as shown for bioactive glass in previous studies where it stimulated osteogenic cell recruitment and differentiation (60,62). The implant particle still presents in the defect and associated with proximal and distal bone remnant by 8 weeks implantation indicates that the composite behaved as an efficient implant for bridging the critical defect a result that was also observed by others in the form of bone substitute bioactive glasses (15,61,63). The signs of remodelling and reduced implant size (23,61) with narrowing gap toward the centre of the defect due to ongoing resorption and a smaller radiodensity confirmed full bridging of the bone defect at the twelve weeks, indicating the successful healing process (64). There were no signs of

complications such as osteolysis or excessive periosteal reaction and according to (65) suggest metaphyseal bone heals faster, with no or limited callus formation, and the implant appeared to have supported the healing process without inducing any significant adverse effects. This phase marked the successful conclusion of the study, showing that the BG implant had facilitated osteointegration, ultimately leading to the repair of the radial bone defect (66, 67).

Conclusions

This study assessed the effectiveness of Bioactive Glass (BG) combined with Acacia Gum (AG) for the repair of substantial segmental radial bone defect in rabbits. The results indicated that bioactive glass with acacia gum has significant biocompatibility, with no complications or negative reactions observed throughout the trial duration. All radiographic assessments indicated that the bioactive glass with acacia gum implant effectively integrated with the bone by enhancing both osteoconductive and osteogenic mechanisms that able to stimulate directly formation of new bone by increasing the proliferation and differentiation of osteoprogenitor cells. The treated group demonstrated improved bone remodeling and formation replacement relative to the control group, which showed inadequate bone healing and non-union at the bone ends.

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Conflict of interest

The authors of this article worked on it and declared that they had no conflicts of interest.

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المعالجة ملئ العيب بغرسة الزجاج الحيوي المخلوط بصمغ الأكاسيا بشكل مضغوط بين الحواف بشكل مناسب في العيب العظمي. نتائج التقييم السريري اظهرت عدم وجود أي علامات تفاعل مناعي او علامات التهابية. في حين أكد الفحص الشعاعي ثبوت الغرسة طوال فترة الدراسة واندماجها مع نهايات القطع العظمي مع تفاعل سمحافي سطحي قليل، بالإضافة إلى صغر حجم وكثافة الغرسة بشكل بطيء من حوافها نتيجة لتحلل الجزيئات البلورية المكونة للمادة مما يدل على الخصائص الموصلة للعظم والمحفزة لتكوينه التي ظهرت في مجموعة المعالجة مقارنة بمجموعة السيطرة التي لم يظهر فيها التئام بسبب حجم العيب الحرج والتي اتسمت بحدوث التحام غير طبيعي أو اتحاد متصالب بين الكعبرة والزند. كما لعب وجود صمغ الأكاسيا دور مهم في تعزيز كبير في القوة الميكانيكية للزجاج الحيوي، مما يشير إلى أداء متفوق في إعادة تشكيل العظام وضمان استقرارها الهيكلي، مما يجعله مناسباً لتطبيقات الزراعة النسيجية العظمية. ومن خلاصة الدراسة اظهر الزجاج النشط بيولوجيا الممزوج بصمغ الأكاسيا انه مادة واعدة لإصلاح عيوب العظام المقطعية، حيث يوفر بديلاً متوافقاً حيويًا وفعالاً مقارنةً بالغرسات التقليدية، كما لم يتم تسجيل أي اثار جانبية معكوسة من قبل الجسم طول فترة الدراسة.

دراسة شعاعية لاستخدام الزجاج النشط بيولوجيا مع صمغ الأكاسيا في إعادة عيوب عظم الكعبرة القطعية في الأرانب

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الخلاصة

هدفت هذه الدراسة الى تقييم فعالية الزجاج النشط بيولوجيا الممزوج بصمغ الأكاسيا لإصلاح عيوب عظم الكعبرة في الارانب. تحت تأثير التخدير العام تم ازالة جزء مقطعي من الجزء القاصي من عمد عظم الكعبرة الايسر تم توزيع الحيوانات الى مجموعتين متساويتين ١٥ لكل واحدة اولا في مجموعة السيطرة تمت ازالة (١٠ ملم) من الجزء القاصي من عمد عظم الكعبرة وترك بدون اي علاج، في حين تم في المجموعة