bonalive

Smart Healing™

Introducing a new
era of healthcare

Bonalive is a smart biomaterials company, transforming healthcare at the intersection of biology and technology. With over 20 years of clinical history, and one of the most evidence-based technologies in the industry, we are re-imagining a smarter future for healthcare.

Content

Bonalive is an ISO 13485:2016 certified, Class III medical device company.

Bonalive® granules, Bonalive® putty and Bonalive® putty MIS are CE marked medical devices.

Bonalive advances the world's transition to sustainable solutions for infection treatment and bone regeneration. We envision a world where bone infections can be treated without antibiotics – a smarter world, for a smarter life.

Smart Healing™

Antimicrobial resistance (AMR) is one of the greatest challenges facing healthcare today. In the face of growing resistance, we need solutions to an increasingly complex global problem. Solutions, that are smarter and more sustainable for patients worldwide.

Coming to life at the intersection of biology and technology, Smart Healing™ represents a new standard. A new era for patient care.

As Smart Healing™ enables increasingly antibiotic free patient care, we provide the world with biomaterial technologies that restore body function through the patient's own biological processes.

Restoring and sustaining patient life. Together.

For patient wellbeing

To enable a faster recovery time, fewer surgeries and a higher quality of life for patients, Smart Healing™ solutions are comprised of natural biological compounds for use in both adult and pediatric patients.

For professionals

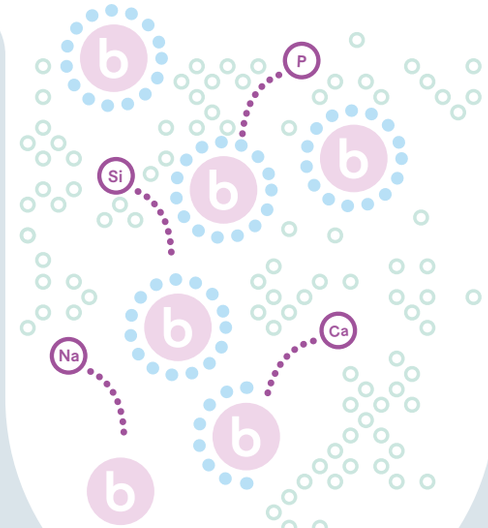
Our solutions aim to minimize the complexity and amount of procedures that medical professionals perform, increasing the capacity of hospital organizations and their personnel to provide better care for more patients.

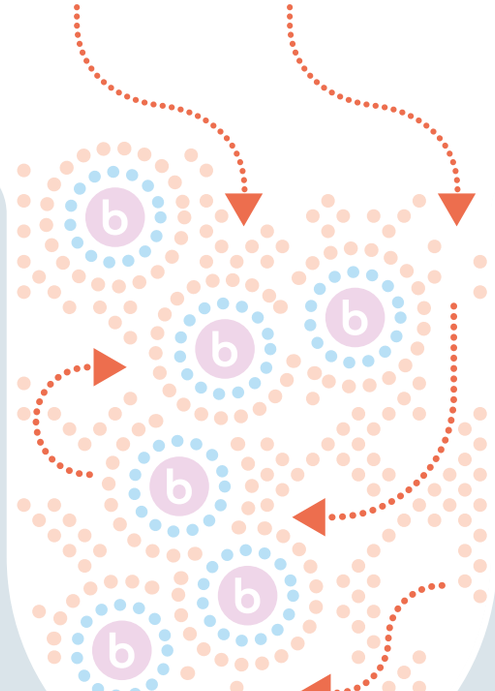
For global healthcare

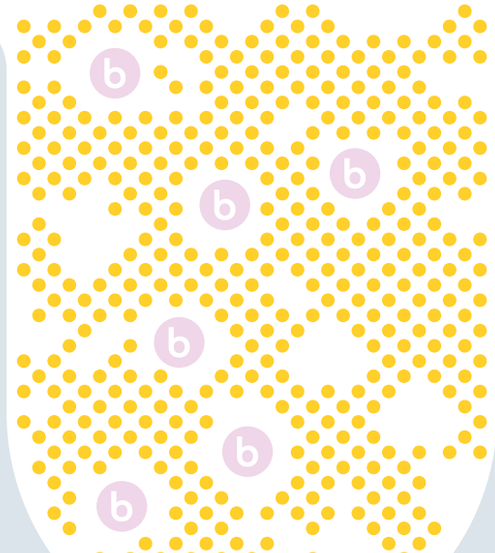
Smart Healing™ enables procedures that are more cost-effective and more sustainable. By aiming to help solve a global problem through improved patient care, Bonalive is committed to creating a better future for the healthcare ecosystem.

Our technology

= S53P4 bioactive glass
= Na, Si, Ca and P ions
= Biological entities
= Body fluids
= Silica gel
= Bone tissue
= Bone consolidation







At the core of our technology is S53P4 bioactive glass – a smart biomaterial consisting solely of elements naturally existing in the human body.

Bonalive® S53P4 bioactive glass is osteoconductive and also osteoproductive in the promotion, migration, replication and differentiation of osteogenic cells and their matrix production.* Bioactive glass S53P4 consists of sodium, silicate, calcium and phosphate.

* Virolainen et al. 1997
** non-osteoinductive

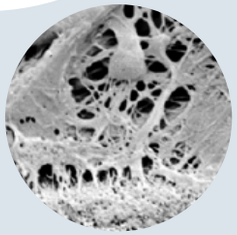
1. Activation

0–12 DAYS

When Bonalive® bioactive glass is placed into the bone cavity, it reacts with body fluids to activate the granules. During this activation period, the bioactive glass goes through a series of chemical reactions, creating the ideal conditions for bone to rebuild through osteoconduction.

- Na, Si, Ca, and P ions are released.
- A silica gel layer forms on the bioactive glass surface.
- CaP crystallizes, forming a layer of hydroxyapatite on the surface of the bioactive glass.

Picture: Hydroxyapatite starts to form on Bonalive® granules surface.



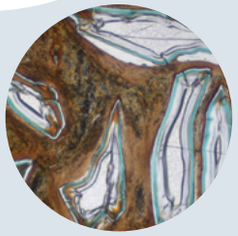
2. Interaction

6–12 WEEKS

Once the hydroxyapatite layer is formed, the bioactive glass interacts with biological entities, i.e. blood proteins, growth factors and collagen. Following this interactive, osteoconductive and osteostimulative** process, new bone grows onto and between the bioactive glass structures.

- Bioactive glass bonds to bone – facilitating new bone formation.
- Osteostimulation** begins by stimulating osteogenic cells to increase the remodeling rate of bone.
- Radio-dense quality of bioactive glass allows for post operative evaluation.

Picture: Bonalive® granules bond to bone and stimulate new bone formation (osteostimulation**).



3. Transformation

MONTHS–YEARS

In the final transformative phase, the process of bone regeneration and remodeling continues. Over time the bone fully regenerates, restoring the patient's natural anatomy.

- Bone consolidation occurs.
- Bonalive® bioactive glass continues to remodel into bone over a period of years.

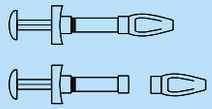
Picture: Histological 20 μm-thick section from the mastoid area a few months after Bonalive® granules implantation.

Pictures 1-2: Courtesy of Turku University Hospital, Finland
Picture 3: Courtesy of Päijät-Häme Central Hospital, Finland

Our products

We offer a range of osteostimulative* technologies to efficiently and cost-effectively restore patient quality of life. Our products facilitate the filling, reconstruction and regeneration of bone defects in both adult and pediatric patients.

Bonalive® granules



A unique bone regeneration technology that naturally inhibits bacterial growth and stimulates bone formation.

Indications

- Bone cavity filling
- Bone cavity filling in the treatment of chronic osteomyelitis
- Mastoid cavity obliteration

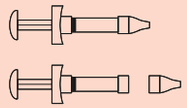
Composition

- 53% SiO_2
- 23% Na_2O
- 20% CaO
- 4% P_2O_5

Properties

- Inhibition of bacterial growth
- Osteoconductive, osteostimulative*

Bonalive® putty



A highly moldable, easy-to-apply bone regeneration technology that naturally stimulates bone formation.

Intended use

- Filling, reconstruction and regeneration of bone defects

Indications for use

- Bony voids and gaps

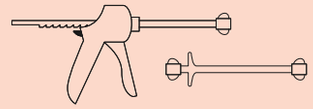
Composition

- 53% SiO_2
- 23% Na_2O
- 20% CaO
- 4% P_2O_5
- Polyethylene glycols (PEGs) and glycerol

Properties

- Osteoconductive, osteostimulative*

Bonalive® putty MIS



A smart bone regeneration technology, providing stable positioning and controlled access in minimally invasive surgery.

Intended use

- Filling, reconstruction and regeneration of bone defects

Indications for use

- Bony voids and gaps

Composition

- 53% SiO_2
- 23% Na_2O
- 20% CaO
- 4% P_2O_5
- Polyethylene glycols (PEGs) and glycerol

Properties

- Osteoconductive, osteostimulative*

* non-osteoinductive

Bonalive® granules

A unique bone regeneration technology that naturally inhibits bacterial growth and stimulates bone formation.

Bonalive® granules is a CE marked Class III medical device, providing a Smart Healing™ solution for bone infections and bone reconstruction. Bonalive® granules has been proven to naturally inhibit the bacterial growth of up to 50 clinically relevant bacteria strains.*

The clinical efficacy and performance of the granules has been proven over the past 20 years in orthopedic, trauma, septic surgery and mastoid surgery. Bonalive® granules is verified as safe for use in pediatric surgery and consists only of elements that are naturally present in the human body.

By supporting the reconstruction of anatomical structures in the human body, the biodegradable S53P4 bioactive glass gets gradually resorbed and replaced by bone over a period of years. Bonalive® granules radio-dense quality enables post-operative evaluation, allowing surgeons to monitor the healing of their patients.

Gram positive bacteria

- *Bacillus cereus*
- *Bifidobacterium adolescentis*
- *Clostridium difficile*
- *Clostridium perfringens*
- *Clostridium septicum*
- *Corynebacterium ulcerans*
- *Enterococcus faecalis*
- *Enterococcus faecium*
- *Eubacterium lentum*
- *Listeria monocytogenes*
- *Micrococcus sp.*
- *Peptostreptococcus anaerobius*
- *Propionibacterium acnes*
- *Propionibacterium propionicus*
- *Staphylococcus aureus*
- *Staphylococcus epidermidis*
- *Streptococcus agalactiae*
- *Streptococcus mutans*
- *Streptococcus pneumoniae*
- *Streptococcus pyogenes*
- *Streptococcus sanguis*

Methicillin-resistant bacteria

- *Pseudomonas aeruginosa*
- *Staphylococcus aureus (MRSA)*
- *Staphylococcus epidermidis (MRSE)*

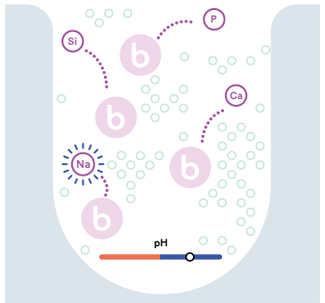
Gram negative bacteria

- *Acinetobacter baumannii*
- *Bacteroides fragilis*
- *Bacteroides thetaiotaomicron*
- *Chryseobacterium (former Flavobacterium) meningosepticum*
- *Enterobacter aerogenes*
- *Enterobacter amnigenus*
- *Escherichia coli*
- *Fusobacterium necrophorum*
- *Fusobacterium nucleatum*
- *Haemophilus influenzae*
- *Klebsiella pneumoniae*
- *Moraxella catarrhalis*
- *Neisseria meningitidis*
- *Pasteurella multocida*
- *Porphyromonas gingivalis*
- *Prevotella intermedia*
- *Prevotella melaninogenica*
- *Proteus mirabilis*
- *Pseudomonas aeruginosa*
- *Salmonella typhimurium*
- *Shigella sonnei*
- *Veillonella parvula*
- *Yersinia enterocolitica*

* Leppäranta et al. 2008; Munukka et al. 2008. See references on page 22.
Drago et al. Antimicrobial activity and resistance selection of different bioglass S53P4 formulations against multidrug resistant strains. Future Microbiol. 2015;10(8):1293-9. / Drago et al. In vitro antibiofilm activity of bioactive glass S53P4. Future Microbiol. 2014;9(5):593–601.

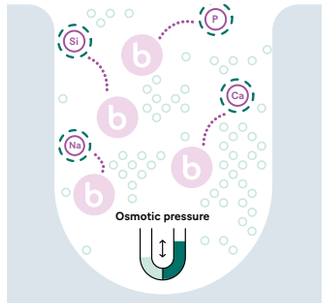
The bacterial growth inhibiting feature of Bonalive® granules is triggered during the granules "Activation" phase, presented on page 8. This phase consists of two simultaneous chemical and physical processes, occurring once the bioactive glass reacts with body fluids.

Increase in pH



1. Sodium (Na) is released from the surface of the bioactive glass and induces an **increase in pH** (alkaline environment), which is not favourable for the bacteria, thus inhibiting their growth.

Increase in osmotic pressure



2. The released Na, Ca, Si and P ions give rise to an **increase in osmotic pressure** due to an elevation in salt concentration, i.e. an environment where bacteria cannot grow.

Bonalive® granules

Na, Si, Ca and P ions

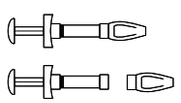
Body fluids

INDICATIONS

- Bone cavity filling
- Bone cavity filling in the treatment of chronic osteomyelitis
- Mastoid cavity obliteration

SPECIFICATIONS

- CE marked
- Class III medical device
- Sterilized
- Available in different granule and unit sizes

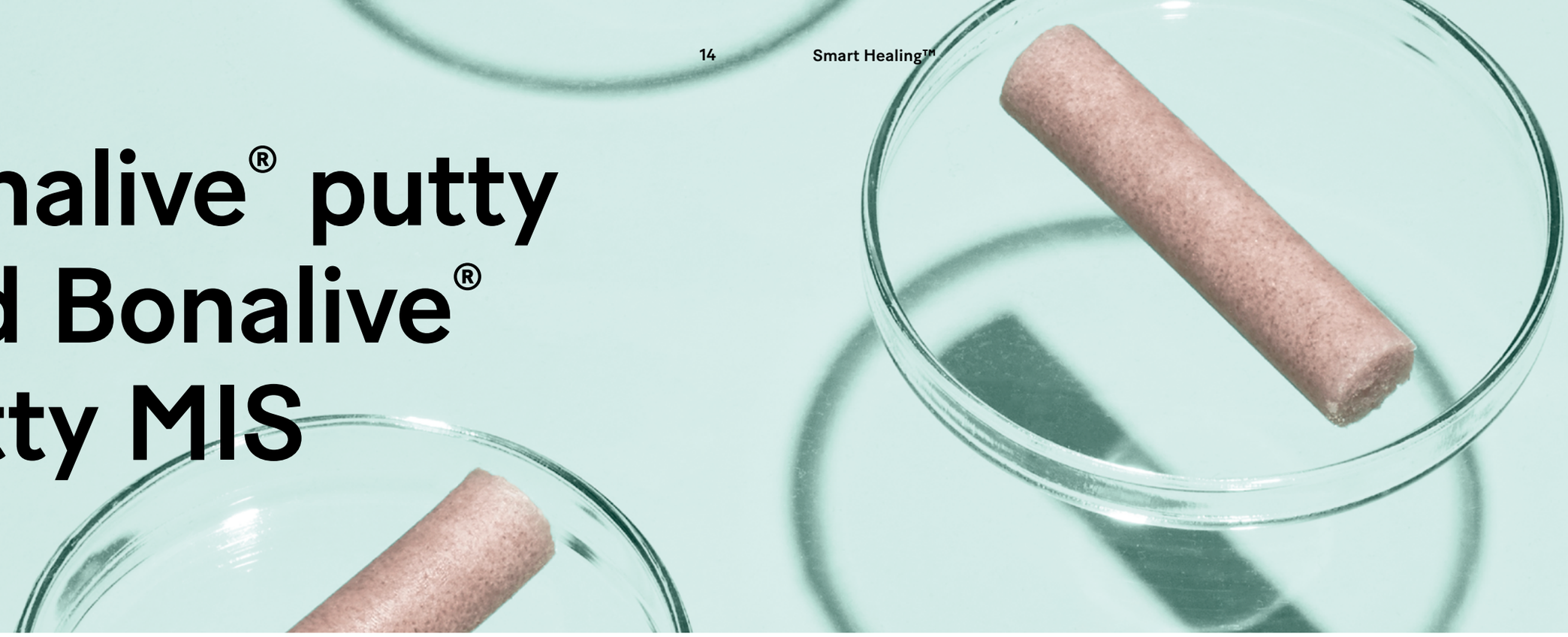


For orthopedic, trauma and septic bone surgery

Unit size	Granule size	Ref. no.
5 cc prefilled applicator	1.0-2.0 mm	13330
10 cc prefilled applicator	1.0-2.0 mm	13340

For ear surgery

Unit size	Granule size	Ref. no.
2.5 cc prefilled applicator	0.5-0.8 mm	13120
5 cc prefilled applicator	0.5-0.8 mm	13130



Bonalive® putty and Bonalive® putty MIS

A highly moldable, easy-to-apply bone regeneration technology that naturally stimulates bone formation.

Bonalive® putty and Bonalive® putty MIS are bioactive, osteoconductive and osteostimulative* synthetic CE marked Class III medical devices. The putty is a synthetic bone graft substitute delivered as a sterile and ready-to-use paste, requiring no mixing, moistening or other preparation. The putty is available in an applicator and in a dispenser delivery system.

The putty consists of S53P4 bioactive glass in addition to a synthetic binder, i.e. a blend of polyethylene glycols (PEGs) and glycerol. The binder allows the putty to stay in place during surgery. Following its application, the binder is absorbed in a few days, leaving behind only the bioactive glass, thus permitting tissue infiltration between the bioactive glass to facilitate bone regeneration.

The putty's radio-dense quality enables post-operative evaluation, allowing surgeons to follow the healing of their patients. Bonalive® putty and Bonalive® putty MIS have not been verified as inhibiting bacterial growth.

* non-osteoinductive

Bonalive® putty

INTENDED USE

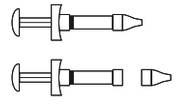
- Filling, reconstruction and regeneration of bone defects

INDICATIONS FOR USE

- Bony voids and gaps

SPECIFICATIONS

- CE marked
- Class III medical device
- Sterilized
- Available in different unit sizes



For orthopedic, trauma, hand and spine surgery in small and medium size defects.

Unit size	Ref. no.
1 cc prefilled applicator	16110
2.5 cc prefilled applicator	16120
5 cc prefilled applicator	16130
10 cc prefilled applicator	16140

Bonalive® putty MIS

INTENDED USE

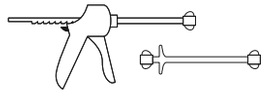
- Filling, reconstruction and regeneration of bone defects

INDICATIONS FOR USE

- Bony voids and gaps

SPECIFICATIONS

- CE marked
- Class III medical device
- Sterilized



For minimally invasive (MIS) bone surgery, especially hard to reach defects.

Unit size	Ref. no.
1 x 5 cc prefilled cartridge with dispenser	18100
1 x 5 cc prefilled cartridge	18131

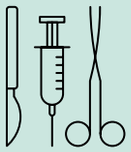
Cost-to-benefit ratio of Bonalive® granules

In a clinical study conducted with 50 patients

Bonalive® S53P4 bioactive glass granules is clinically proven to be a cost-effective and sustainable solution in the treatment of chronic osteomyelitis.

Bone infections are characterized by progressive infection resulting in the destruction of bone. Patients who undergo surgery for septic bone may be hospitalized for long periods of time, often developing a resistance to antibiotics.

In cases where the cavitary defect allows sufficient debridement of the necrotic tissue, the granules can be used in a one-stage procedure. Simultaneous with the inhibiting of bacterial growth, the granules heal the bone cavity by stimulating bone formation. This enables a smarter, more sustainable and cost-effective healing solution, reducing the length of hospital stays, while creating significant value across the entire healthcare ecosystem.*



46%

Less surgeries

T. Group: 1.3 surgeries
C. Group: 2.4 surgeries

39%

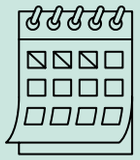
Shorter hospital stays

T. Group: 17.8 days
C. Group: 29.3 days

16%

Higher success rate of eradication of infection

T. Group: 96%
C. Group: 80%



28%

Fewer follow-up procedures

T. Group: 11.8 months
C. Group: 16.4 months

Study groups

- **Treatment group (T)**
- **Control group (C)**

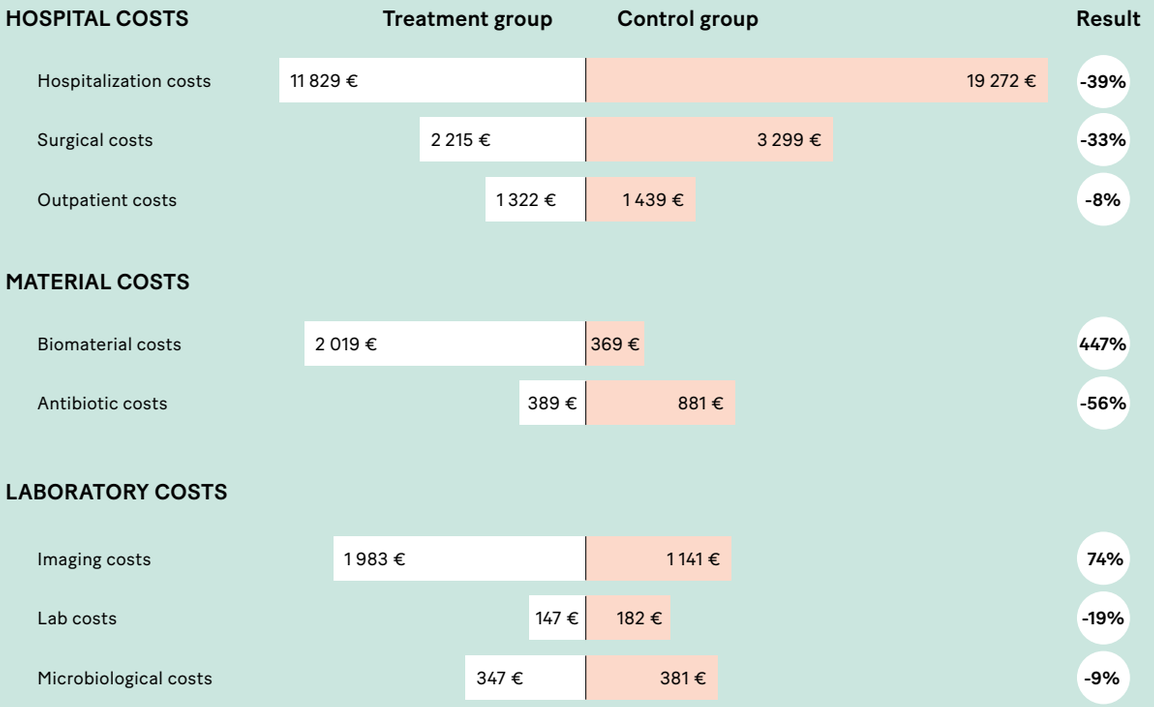
* The cost effectiveness of Bonalive® S53P4 bioactive glass granules was measured in a retrospective cohort study, of patients diagnosed with long bone chronic osteomyelitis. The study was carried out at Maastricht University Medical Center+. All the results and cost benefits presented here have been calculated with a minimum of 1 year patient follow-up.
** 40 574€ savings per patient according to incremental cost-effectiveness ratio (ICER)

96% success rate

11.5 days shorter hospital stays for patients

24% cost decrease per patient

6 713€ direct savings per patient **



Study details

- **Treatment group (T)**
- **Control group (C)**

Patients were split into two groups:

- Treatment group: 25 patients were treated with Bonalive® S53P4 bioactive glass granules, in a 1-stage surgery.
- Control group: 25 patients were treated with gentamicin loaded PMMA bead chains, in a 2-stage surgery.

Bonalive® protocol with a 1-stage surgery

Surgery:
- Surgical debridement
- Implantation of S53P4 bioactive glass granules

Antibiotic treatment:
- Culture specific
- Intravenous 14 days
- Oral 28 days

Antibiotic (PMMA) protocol with a 2-stage surgery

Surgeries:

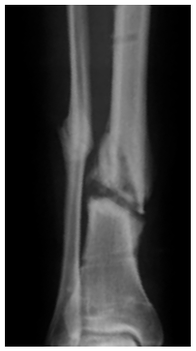
Stage 1
- Surgical debridement
- Implantation of PMMA beads

Stage 2
- Removal of PMMA beads
- Defect filling with autologous bone graft or allograft

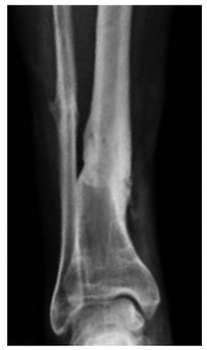
Antibiotic treatment:
- Culture specific
- Intravenous 14 days
- Oral 28 days

Areas of use

Our Smart Healing™ solutions can be used in both adult and pediatric patients, providing significant benefits to both patients and medical professionals. Areas of use include a wide range of indications that require the filling of bone cavities, voids and gaps as well as the reconstruction or regeneration of bone defects.



Pre-op



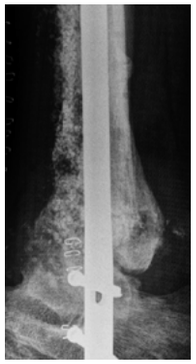
2 years post-op

Bone infection: Septic non-union

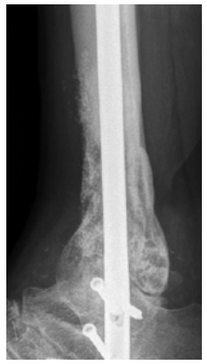
After thorough debridement and decortication of the bone of the necrotic area, Bonalive® granules can be used to effectively resolve even the most challenging septic non-unions. Due to the inhibition of bacterial growth, the use of local antibiotics is not necessary, making Bonalive® granules a distinctly sustainable solution for septic non-union procedures.

Case: Septic non-union with Staphylococcus aureus developed 9 months after trauma. The external fixator was removed and an osteotomy of the fibula and the debridement of the septic non-union site was performed after 15 days. The bone gap was grafted with 20 cc Bonalive® granules mixed with an equal amount of autograft. The fixation, which was performed with intramedullary nailing, was removed during a follow-up 18 months later. Bone healing was achieved 6 months after implantation. The soft tissue healed well without any clinical or laboratory signs of infection recurrence. The dynamization of the nail was performed 14 months post-op and the nail was removed 2 years post-op.

Pictures: Courtesy of Istituto Ortopedico Galeazzi, Italy



Immediate post-op



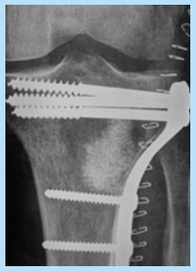
2.5 years post-op

Bone infection: Chronic osteomyelitis

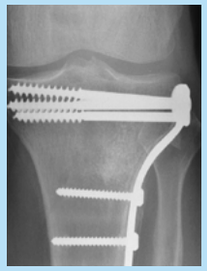
Bonalive® granules have proven effective for bone cavity filling in chronic osteomyelitis treatment. In cases where the cavitary defect allows the sufficient debridement of the necrotic tissue, the granules can be used in a one-stage procedure. Simultaneous with the inhibiting of bacterial growth, the granules stimulate bone formation. This enables cost-effective healing and reduces the length of hospital stays.

Case: Careful debridement and the filling of a 100 cc size defect with 48 cc Bonalive® granules mixed with an equal amount of autologous bone in a one-stage procedure. Although a significant part of the anterior cortex of the distal tibia was removed, new cortical bone was formed. At 2.5 years post-op the fusion was stable.

Pictures: Courtesy of Turku University Hospital, Finland



Immediate post-op



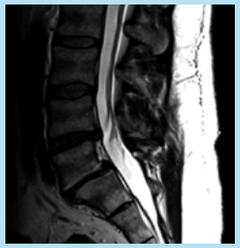
11 years post-op

Trauma

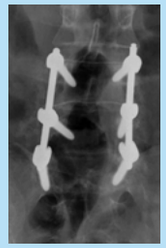
The use of Bonalive® granules in trauma surgery is supported by long-term randomized prospective clinical trials with follow-up extending to 11 years, with long-term results comparable to autograft. The solid nature of Bonalive® granules provides specific benefits, such as allowing the granules to be impacted into the bone defect. The granules maintain their volume effectively, hence they do not shrink or expand. Bonalive® granules remodels slowly to bone, thus allowing sufficient time for bone regeneration.

Case: Depressed tibial plateau fracture was filled with 15 cc Bonalive® granules and supported with an anatomical condylar plate. At 11 years post-op, Bonalive® granules has completely remodeled to bone.

Pictures: Courtesy of Turku University Hospital, Finland



Pre-op



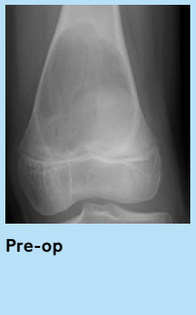
12 months post-op

Spine

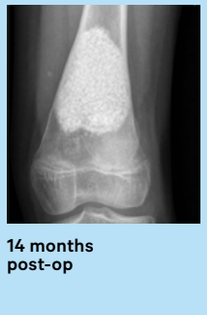
Due to restrictions in the local harvesting of bone graft, minimal invasive surgical (MIS) spine fusion procedures limit the use of autograft. The MIS device enables easy access to bone voids or gaps that are difficult to reach with conventional surgical devices. By stimulating new bone formation through osteostimulation*, Bonalive® putty MIS produces a high but balanced local bone turnover.

Case: MIS fusion in the degenerative spine. The cages and disc space were filled with Bonalive® putty. In addition, a posterolateral fusion was performed on the right side by using autograft mixed with Bonalive® putty. At 3-month post-op, the patient was free from medication and was able to walk 12 km.

Pictures: Courtesy of Turku University Hospital, Finland



Pre-op



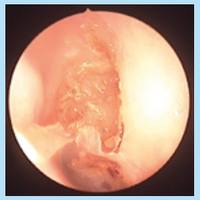
14 months post-op

Benign bone tumor

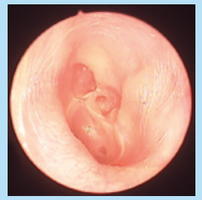
Pediatric orthopedic surgery is a special focus area of Bonalive® products. The long-term use of Bonalive® granules for treating bone defects created by benign bone tumors, e.g. enchondromas, simple cysts and aneurysmal bone cysts, has shown the granules remodel slowly to bone in the grafted area, without disturbing the normal growth of bone in children.

Case: Large bone cyst (ABC/UBC) in a 11-year-old child was carefully evacuated and the dead space was filled with 50 cc of Bonalive® granules covered with 5 cc of Bonalive® putty. At 14-month post-op, the distal end of the femur had grown 12 mm and the patient was asymptomatic and active in playing sports.

Pictures: Courtesy of Helsinki University Hospital, Finland



Pre-op



14 months post-op

Mastoid surgery

Long-term studies have shown that mastoid cavities with continuous infections and cleaning difficulties can be successfully obliterated with Bonalive® granules. The bacterial growth inhibiting feature and remodeling profile of the granules enables significant advantages when performing cholesteatoma and mastoid obliteration surgery. In addition, the osteostimulative* property of Bonalive® granules supports new tissue formation in the mastoid cavity.

Case: The obliteration of a radical mastoid cavity with cholesteatoma. A 76-year-old patient who had undergone a tympanoplasty (canal wall down) and meatoplasty (cartilage) of her left ear 40 years ago. Recurrent secretion which resulted in frequent intervals of treatment every 2 weeks and wearing a hearing aid caused problems. Excessive cholesteatoma was removed and thorough cleaning was performed. The mastoid and attic were obliterated with 3.5 cc of Bonalive® granules. At 14 months, the healing had progressed well but showed a slight retraction towards the attic. At 24 months the meatus was normal, and the patient had no problems wearing a hearing aid.

Pictures: Courtesy of Zentrums für Mittelohrchirurgie in Lünen, Germany

* non-osteoinductive

Supporting services

We offer a range of tools and services to support healthcare professionals in using our products. Proactive education and engagement with our network of surgeons, doctors and other medical professionals allows us to swiftly onboard hospital organizations with Bonalive® products.

References

Our comprehensive list of references provides data supporting the use of our products in a wide range of indications. Our peer-reviewed references are a valuable resource for professionals interested in our technology and its applications.

- In vitro
- Preclinical
- Clinical
- Book literature

As new studies emerge regularly, the up-to-date reference list can be accessed by request via our website.

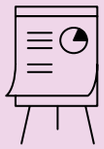
Medical education

We offer a range of medical education tools to help familiarize and onboard healthcare professionals with our Smart Healing™ technologies. Our indication specific brochures provide insight into surgical application, product usage and supporting examples of patient cases.

- Live surgeries
- Indication specific brochures
- Medical information services

Submit any questions that may arise to medical.info@bonalive.com

Events



We are present at relevant medical conferences each year, where we enable peer-to-peer support and education for healthcare professionals.

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- Seminars

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References

We have accumulated over 150 references throughout the past two decades. Those presented here provide an overview of the most notable publications and studies. As new studies emerge regularly, the up-to-date reference list can be accessed by request.

150+ references


In vitro


Preclinical


Clinical


Book literature

IN VITRO

In vitro antibacterial activity of bioactive glass S53P4 on multiresistant pathogens causing osteomyelitis and prosthetic joint infection.
Cunha TM, Murça MA, Nigro S, Klautau GB, Salles MJC. BMC Infectious Diseases. 2018;18:157.

Influence of bioactive glass S53P4 granules and putty on osteomyelitis associated bacteria in vitro
Stoor P, Frantzén F. Biomedical Glasses 2017;3(1):79-85.

Antibiofilm agents against MDR bacterial strains: is bioactive glass BAG-S53P4 also effective?
Bortolin M, De Vecchi E, Romanò CL, Toscano M, Mattina R and Drago L. J Antimicrob Chemother. 2016 Jan;71(1):123-7.

Bactericidal effects of bioactive glasses on clinically important aerobic bacteria.
Munukka E, Leppäranta O, Korkeamäki M, Vaahtio M, Peltola T, Zhang D, et al. J Mater Sci: Mater Med. 2008;19:27-32.

Antibacterial effect of bioactive glasses on clinically important anaerobic bacteria in vitro.
Leppäranta O, Vaahtio M, Peltola T, Zhang D, Hupa L, Hupa M, et al. J Mater Sci: Mater Med. 2008;19:547-51.

Molecular basis for action of bioactive glasses as bone graft substitute.
Välimäki VV, Aro HT. Scandinavian Journal of Surgery. 2006;95(2):95-102.

Histomorphometric and molecular biologic comparison of bioactive glass granules and autogenous bone grafts in augmentation of bone defect healing.
Virolainen P, Heikkilä J, Yli-Urpo A, Vuorio E, Aro HT. J Biomed Mater Res. 1997;35B(1):9-17.

PRECLINICAL

Polymer-coated bioactive glass S53P4 increases VEGF and TNF expression in an induced membrane model in vivo.
Björkenheim R, Strömberg G, Pajarinen J, Ainola M, Uppstu P, Hupa L, Böhling TO, Lindfors NC. Journal of Materials Science 2017;52(15):9055–65.

BAG S53P4 putty as bone graft substitute – a rabbit model.
Saarenpää I, Stoor P, Frantzén J. Biomed Glasses. 2017;3:30-40.

EAR, NOSE AND THROAT
Mastoid surgery

Mastoid obliteration with S53P4 bioactive glass in cholesteatoma surgery.
de Veij Mestdagh P, Colnot D, Borggreven P, Orelio C,Quak J. Acta Oto-Laryngologica 2017;137(7):690-4.

Anatomical, functional and quality-of-life results for mastoid and epitympanic obliteration with bioactive glass S53P4: a prospective clinical study.
Bernardeschi D, Pyatigorskaya N, Russo FY, De Seta D, Corallo G, Ferrary E, et al. Clin Otolaryngol. 2017;42(2):387-96.

ORTHOPEDICS
Bone infection

The use of bioactive glass S53P4 as bone graft substitute in the treatment of chronic osteomyelitis and infected non-unions – a retrospective study of 50 patients.
Malat TA, Glombitza M, Dahmen J, Hax PM, Steinhausen E. Z Orthop Unfall 2018;156(2):152–9.

Antibacterial bioactive glass, S53P4, for chronic bone infections – a multinational study.
Lindfors NC, Geurts J, Drago L, Arts JJ, Juutilainen V, Hyvönen P, et al. Adv Exp Med Biol. 2017;971:81-92.

A comparative study of the use of bioactive glass S53P4 and antibiotic-loaded calcium-based bone substitutes in the treatment of chronic osteomyelitis – a retrospective comparative study.
Romanò CL, Logoluso N, Meani E, Romanò D, De Vecchi E, Vassena C, Drago L. Bone Joint J 2014;96-B:845-50.

ORTHOPEDICS
Trauma

Bioactive glass S53P4 and autograft bone in treatment of depressed tibial plateau fractures. A prospective randomized 11- year follow-up.
Pernaa K, Koski I, Mattila K, Gullichsen E, Heikkilä J, Aho A, Lindfors N. J Long-term Eff Med Impl. 2011;21(2):139-48.

ORTHOPEDICS
Benign bone tumor

A prospective randomized 14-year follow-up study of bioactive glass and autogenous bone as bone graft substitutes in benign bone tumors.
Lindfors NC, Koski I, Heikkilä JT, Mattila K, Aho AJ. J Biomed Mater Res. 2010;94A(1):157-64.

ORTHOPEDICS
Spine

Instrumented spondylodesis in degenerative spondylolisthesis with bioactive glass and autologous bone. A prospective 11-year follow-up.
Frantzén J, Rantakokko J, Aro H, Heinänen J, Kajander S, Gullichsen E, Kotilainen E, Lindfors N. J Spinal Disorder Tech. 2011;24(7):455-61.