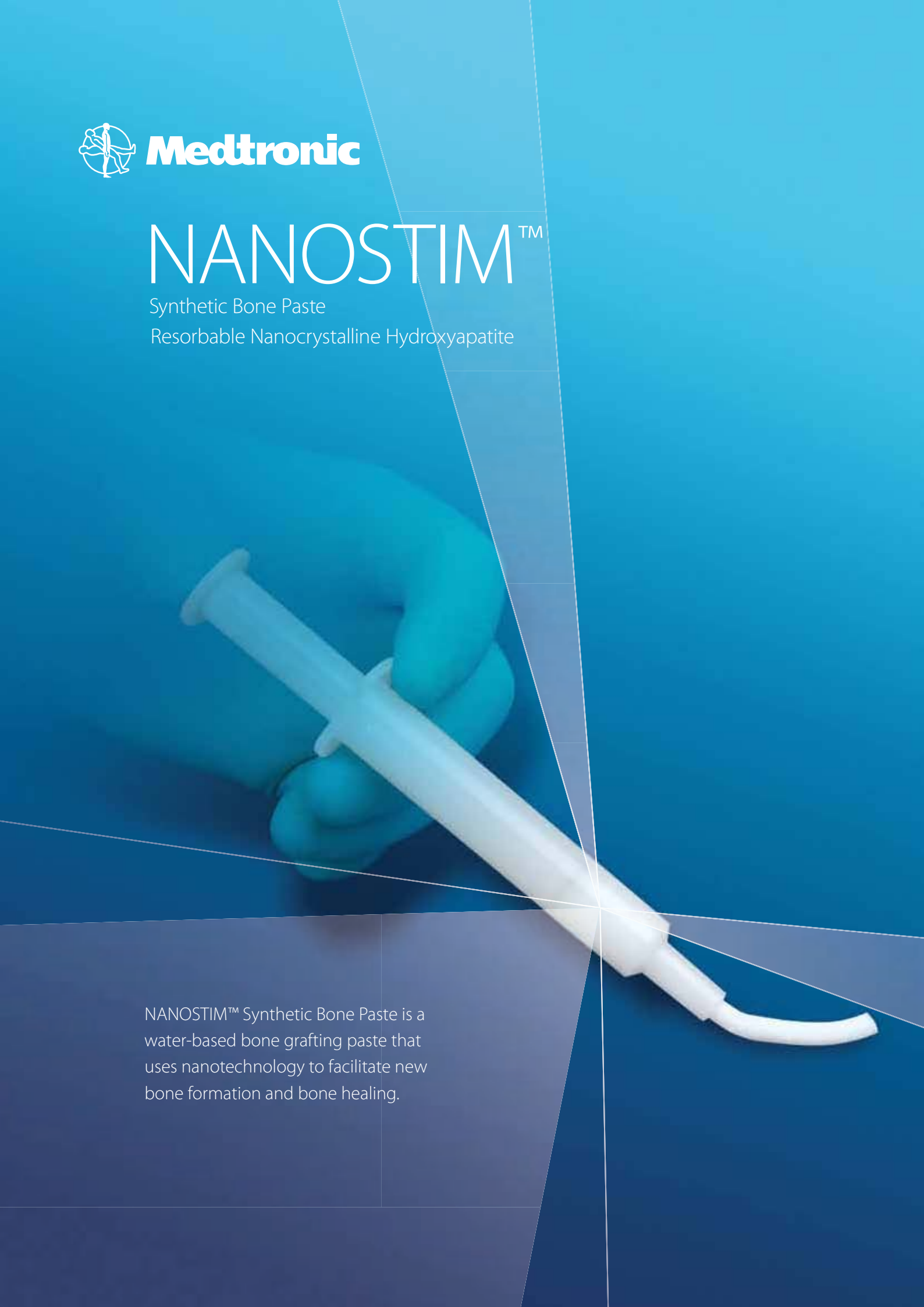
Medtronic

NANOSTIM™

Synthetic Bone Paste

Resorbable Nanocrystalline Hydroxyapatite



NANOSTIM™ Synthetic Bone Paste is a water-based bone grafting paste that uses nanotechnology to facilitate new bone formation and bone healing.

What is NANOSTIM™ Synthetic Bone Paste?

NANOSTIM™ Synthetic Bone Paste is a resorbable, nanocrystalline hydroxyapatite bone grafting paste with osteoconductive properties that facilitate new bone formation and bone healing. Delivered in a syringe, NANOSTIM™ Synthetic Bone Paste is ready-to-use in the filling and reconstruction of bone defects in orthopaedics, traumatology and neurosurgery.

NANOSTIM™ Synthetic Bone Paste is a non-hardening, pure, calcium phosphate product set in a matrix of sterile water. The water-based nature of NANOSTIM™ Synthetic Bone Paste allows blood to easily integrate into the nanostructured material.*

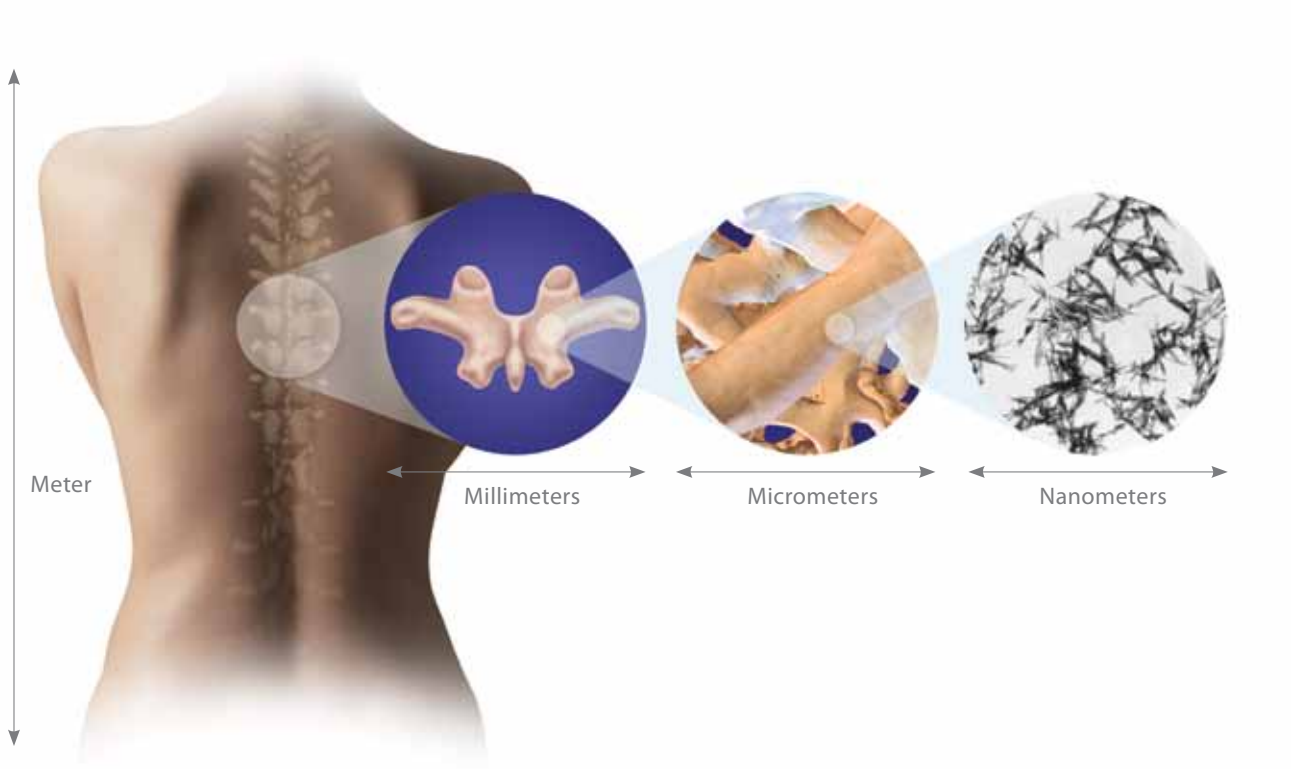


Illustration of nano-size

* Laschke M.W., Witt K., Pohlemann T., Menger M.D.: Injectable nanocrystalline hydroxyapatite paste for bone substitution: In vivo analysis of biocompatibility and vascularization. *Journal of Biomedical Materials Research Part B: Applied Biomaterials 2007*. 82B.494-505, 2007.

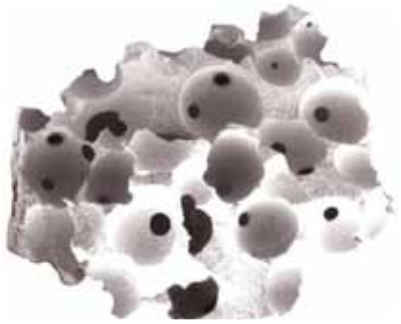
NANOSTIM™ Synthetic Bone Paste Is Resorbable

Tiny crystals with large surface area

NANOSTIM™ Synthetic Bone Paste consists of pure nanocrystals that are less than 20 nanometers (nm) in size embedded in a matrix of sterile water. Due to this unique nanostructure, NANOSTIM™ Synthetic Bone Paste has a high surface-to-weight ratio which provides the surgeon with a novel synthetic bone grafting option.

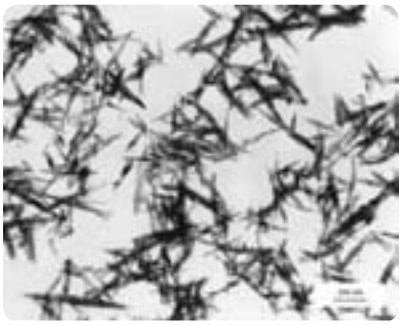
NANOSTIM™ Synthetic Bone Paste is resorbable by osteoclastic mechanisms, is stable and does not dissolve in water.

Nanotechnology in synthetic bone paste



Conventional synthetic granules
Exposed surface area[1]: approximately 2m^2/g

Through technological advances, HA powder in its raw material form can be molded and transformed into complex shapes to mimic trabecular bone. This improves the surface area of the HA exposed to patient's blood upon implantation, and provides a better osteoconductive scaffold for bone growth than the synthetic hydroxyapatite powder.



NANOSTIM™ Synthetic Bone Paste
Exposed surface area[2]: approximately 100m^2/g

Recent advances in nanotechnology allow for a finer and smaller crystal size. Trabecular bone is no longer mimicked as with synthetic granules, rather the bone crystal itself is mimicked on the nanoscale level. This results in a scaffold with a high surface-to-weight ratio, and allows for HA to be resorbed following implantation.

1. Le Nihouannen D, Daculsi G, Saffarzadeh A, Gauthier O, Delplace S, Pilet P, Layrolle P. Ectopic bone formation by microporous calcium phosphate ceramic particles in sheep muscles. *Bone*. 2005 Jun;36(6):1086-1093.

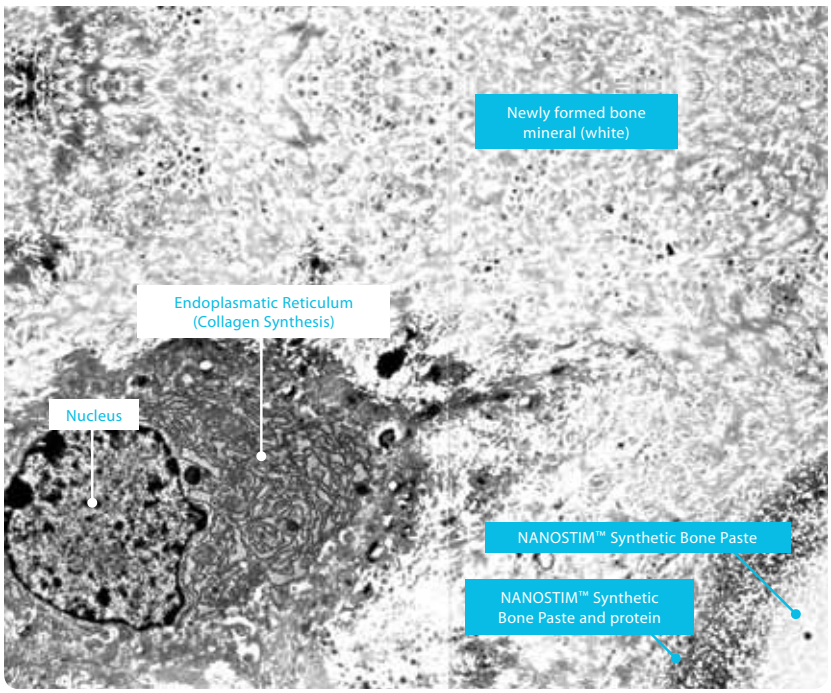
2. Huber FX, Hillmeier J, Herzog L, McArthur N, Kock HJ, Meeder PJ. Open reduction and palmar plate-osteosynthesis in combination with a nanocrystalline hydroxyapatite spacer in the treatment of comminuted fractures of the distal radius. *J Hand Surg Br.* 2006 Jun;31(3):298-303.

Resorption of NANOSTIM™ Synthetic Bone Paste

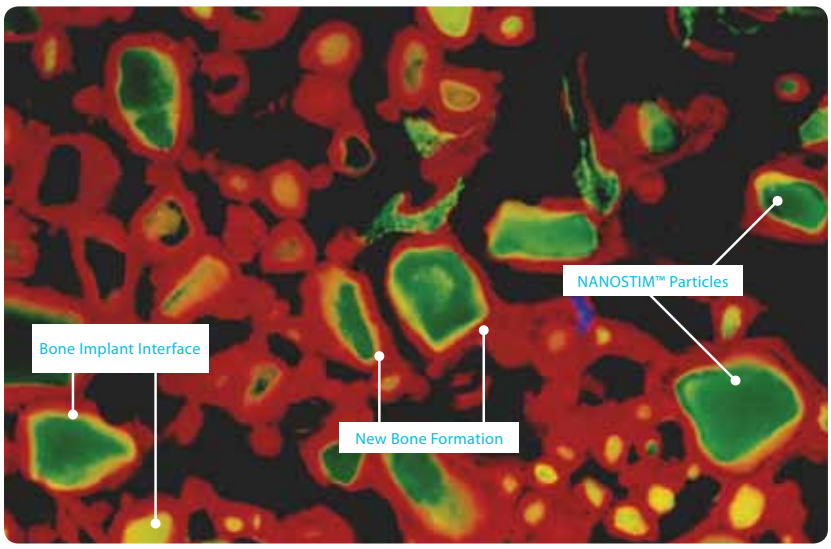
New bone formation occurs simultaneously with the resorption of NANOSTIM™ Synthetic Bone Paste.

As osteoblast precursor cells differentiate, they proliferate and form woven bone which is remodeled into lamellar bone at a later stage.

At right is a magnified TEM image (×5763) of an osteoblast transforming into an osteocyte around neighbouring Nanostim™ Particles visible in the lower right corner. The osteoblast is surrounded by a small zone of non-mineralised organic substance. The prominent endoplasmatic reticulum indicates a high synthetic activity. Furthermore, the collagen matrix is nearly completely mineralised which is indicated by the white colour and the outer surface contains organic material (dark colour).

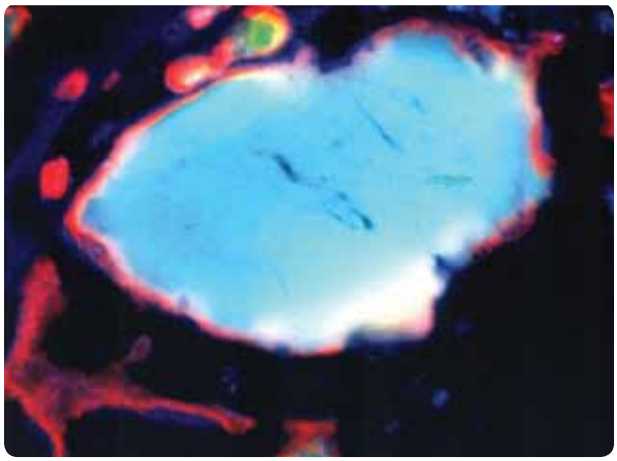


Fluorescent microscopy image shows a bone defect filled with NANOSTIM™ Nanocrystals in a preclinical model 30 days following implantation. The image highlights new bone formation (red) along with the bone-implant interface (yellow) surrounding the partially resorbed NANOSTIM™ Nanocrystals (green).



NANOSTIM™ Synthetic Bone Paste Preclinical Evidence* Showing Bone Formation and Cell Biology Mechanisms

The nanocrystallinity of NANOSTIM™ Synthetic Bone Paste allows for a large, active surface area.[6,7] Preclinical evidence demonstrate NANOSTIM™ Synthetic Bone Paste as a matrix for cell attachment and migration.[8]

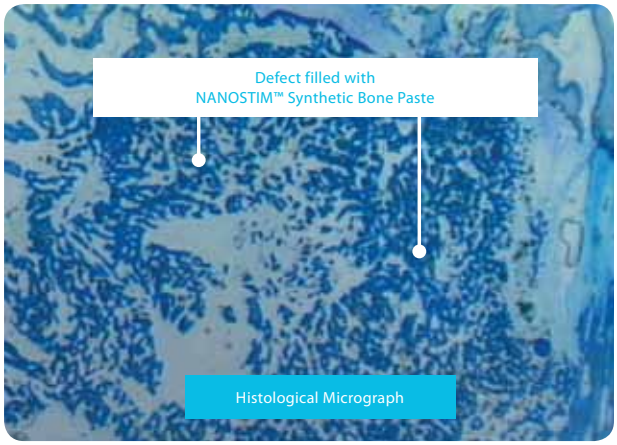


Red areas: newly formed bone 21 days post-operatively in a preclinical model.

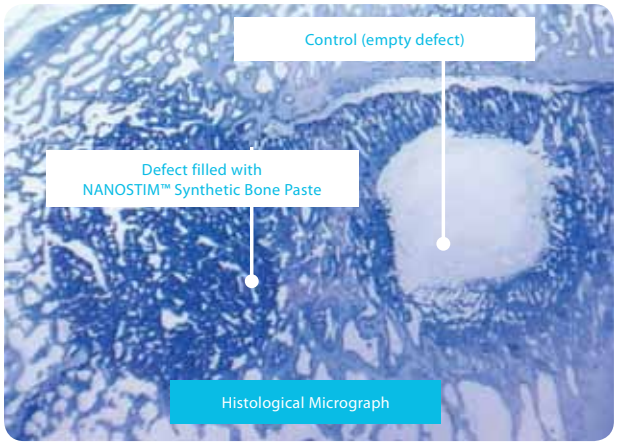
Blue-green areas: nanocrystalline NANOSTIM™ residuals. Note the new bone growth on the surface of the NANOSTIM™ Nanocrystal.

Cell migration and activation of osteoblastic and osteoclastic activity

Following vascularisation, osteoprogenitor cells migrate into the matrix of NANOSTIM™ Synthetic Bone Paste, leading to the formation of new bone, and the initiation of the resorption of NANOSTIM™ Synthetic Bone Paste.



New bone formation in a critical sized defect 30 days post-operatively in a preclinical sheep model.

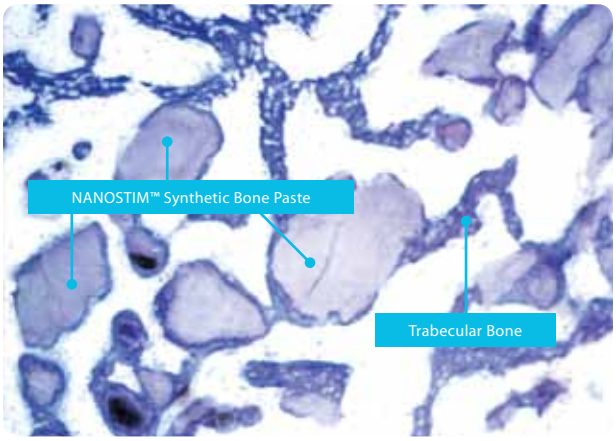


Comparison of new bone formation in two critical sized defects 60 days post-operatively in a preclinical model. Note the reduced new bone formation in the unfilled defect (right) compared to the defect filled with NANOSTIM™ Synthetic Bone Paste (left).

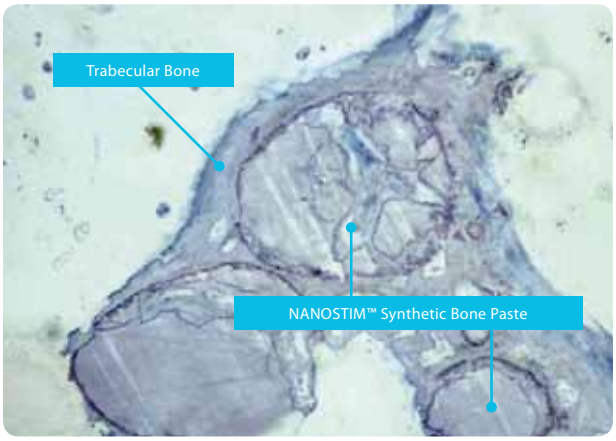
* Animal testing is not necessarily indicative of human clinical outcomes.

Resorption of NANOSTIM™ Synthetic Bone Paste

NANOSTIM™ Synthetic Bone Paste is phagocytosed by macrophages and osteoclasts and the resorption takes place over a period of several months, depending on the osteoclastic activity of the patient.



Histological slide showing NANOSTIM™ surrounded by newly formed bone 30 days post-operatively in a preclinical model. Note the well-defined formation of trabecular bone around the nanocrystalline NANOSTIM™ residuals.



Immunohistochemical slide showing NANOSTIM™ Synthetic Bone Paste and the cell nucleus of an osteoblast surrounded by a mineralising osteoid attached to the surface of NANOSTIM™ Synthetic Bone Paste 30 days post-operatively in a preclinical model.

NANOSTIM™ Synthetic Bone Paste Clinical Evidence in Orthopaedic Applications

Evidence for	Author	Indications	Method/Material
Treatment of calcaneal fractures by stable calcaneous plate in combination with NANOSTIM™ Synthetic Bone Paste results in good restorage of joint flexiblity[1]	Huber (2006)	Human study involving intraarticular calcaneous fractures	24 fractures were supplemented with NANOSTIM™ Synthetic Bone Paste and stabilized by a calcaneal honeycomb plate
Degradation of NANOSTIM™ Synthetic Bone Paste and bony integration of remnants in human cancellous bone tissue[2]	Huber (2006)	Reconstructive bone surgery of tibial, calcaneal and radius fractures in humans	Histological and immunohistochemical analysis of human biopsies
Early consolidation of tibial head osteotomies[3]	Schwartz (2006)	Tibia osteotomy in humans	Open wedge tibia osteotomy stabilized with a plate and filling of the osteotomy gap with NANOSTIM™ Synthetic Bone Paste without addition of autograft
Decrease of complication rate in distal radius fractures class II and III[4]	Huber (2006)	Comminuted fractures of the distal radius in humans	Palmar plate osteosynthesis with angularly stable T-plates and application of hydroxyapatite paste and evaluation with standardized digital radiograph. Clinical examination was carried out according to the standardized checklist of the AO organization.
Effect on stability of joint reduction after treatment of tibia compression fracture zones using NANOSTIM™ Synthetic Bone Paste in combination with a HA ceramic[5]	Huber (2006)	Human tibia compression fractures, type B2, B3, C3, C2	Prospective study including 24 patients. Fractures were stabilized by plate after anatomical reduction. The fracture cavities were filled partially with NANOSTIM™ Synthetic Bone Paste followed by insertion of HA ceramic bloc.

1 Huber F.X., Hillmeier J., McArthur N., Kock H.J., Meeder P.J.: The Use of Nanocrystalline Hydroxyapatite for the Reconstruction of Calcaneal Fractures: Preliminary Results. The Journal of Foot & Ankle Surgery 2006;45(5):322-328

2 Huber F.X., Belyaev O., Hillmeier J., Kock H.J., Huber C., Meeder P.J., Berger I.: First histological observations on the incorporation of a novel nanocrystalline hydroxyapatite paste OSTIM® in human cancellous bone. BMC Musculoskeletal Disorders 2006 (08 June);7:50

3 Schwartz C., Dingeldein E.: The use of a nanoparticles hydroxyapatite gel as a bone substitute. 92. Congress of the Deutsche Gesellschaft für Orthopädie und Orthopädische Chirurgie e.V. (DGOOC), Berlin, 2006

4 Huber F.X., Hillmeier J., Herzog L., McArthur N., Kock H.J., Meeder P.J.: Open reduction and palmar plate-osteosynthesis in combination with a nanocrystalline hydroxyapatite spacer in the treatment of comminuted fractures of the distal radius. Journal of Hand Surgery (British and European Volume) 2006;31B:3:298-303

NANOSTIM™ Synthetic Bone Paste Clinical Evidence in Orthopaedic Applications

Results	Conclusion
Good restoration of Böhler's angle, Gissane's angle and height resulting in a mean functional Creighton-Nebraska score of 86 ± 10.	Use of NANOSTIM™ Synthetic Bone Paste in open reduction with plate fixation presents a good and reliable surgical technique for treatment of calcaneous fractures.
Histological confirmation of new bone formation, degradation of NANOSTIM™ Synthetic Bone Paste and bony integration of remaining NANOSTIM™ Synthetic Bone Paste by direct formation of bone on the bone substitute material. Immunohistochemically the presence of osteoblasts and a low number of macrophages was shown.	NANOSTIM™ Synthetic Bone Paste exhibits excellent biocompatibility. It is degraded to a high extent within 3 to 15 months depending on the indication. Residuae are incorporated into new bone.
In total of 50 tibia osteotomies consolidation was achieved within 6 weeks in 49 cases. Histological investigation of biopsies taken 6-12 weeks post op showed partial resorption and tissue integration of NANOSTIM™ Synthetic Bone Paste and formation of dense new bone trabeculae.	Application of NANOSTIM™ Synthetic Bone Paste ensures a fast consolidation after open wedge osteotomy.
From a total of 23 fractures 19 were rated as excellent and good. Decrease of radioulnar inclination and dorsopalmar tilt was 10% and 17% respectively.	Use of NANOSTIM™ Synthetic Bone Paste leads to a stable bony reconstitution of the distal radius accompanied by a low complication rate.
A Rasmussen score of 26 ± 5.2 was achieved one year post op and the mean loss of correction was 1.8 mm ± 1.2 one year post op.	Combination of NANOSTIM™ Synthetic Bone Paste and Cerabone leads to a stable joint reduction with minor loss of correction and timely new bone formation.

5 Huber F.X., McArthur N., Hillmeier J., Kock H.J., Baier M., Diwo M., Berger I., Meeder P.J.: Void filling of tibia compression fractures zones using a novel resorbable nanocrystalline hydroxyapatite paste in combination with a hydroxyapatite ceramic core: first clinical results. Arch Orthop Trauma Surg 2006;126(8):533-540

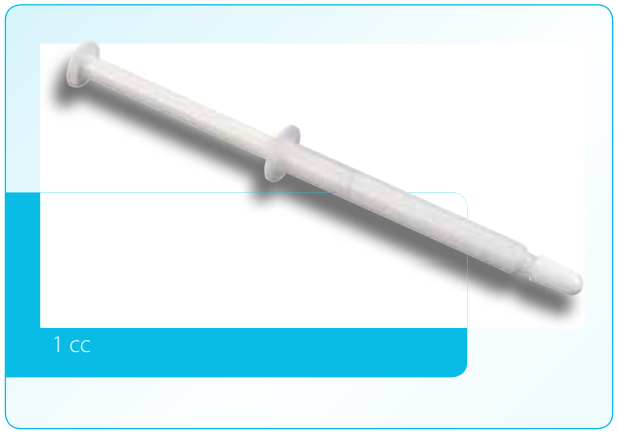
6 Huber F.X., Berger I., McArthur N., Huber C., Kock H.P., Hillmeier J., Meeder P.J.: Evaluation of a novel nanocrystalline Hydroxyapatite paste and a solid hydroxyapatite ceramic for the treatment of critical size defects (CSD) in rabbits. J Mater Sci: Mater Med 2006

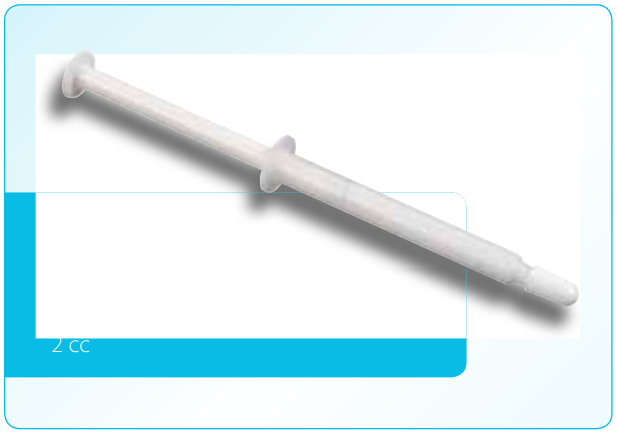
7 Kilian O., Volker A., Heiss C., Jonuleit T., Dingeldein E., Flesch I., Fidorra U., Wenisch S., Schnettler R.: New blood vessel formation and expression of VEGF receptors after implantation of platelet growth factor-enriched biodegradable nanocrystalline hydroxyapatite. Growth Factors 2005;23(2):125-133

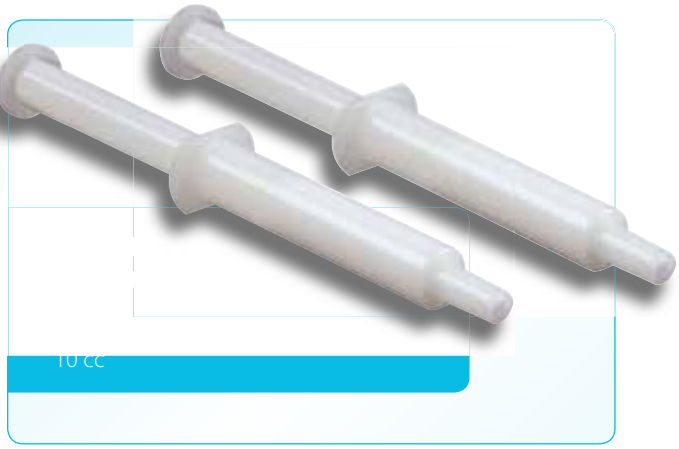
8 Schnettler R., Kilian O., Alt V., Wenisch S.: Potentiation of Osteogenesis and Angiogenesis In Vivo after Implantation of Hydroxyapatite Combined with Autogenous Growth Factors. Osteo Trauma Care 2004;12:170-173

NANOSTIM™ Synthetic Bone Paste
Resorbable Nanocrystalline Hydroxyapatite

Ordering Information







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