Timplant®

dental implants

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DEVELOPMENT, DESIGN AND SURGICAL APPLICATION OF 2.0 MM NANOSTRUCTURED DENTAL IMPLANT

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Assumption 1

.
When designing the implant, we assumed the resulting implant diameter to be between 1.8 to 2.2 mm. We made dozens of experiments and calculations. These experiments along with calculations were used to determine the final diameter of the implant prototype. In spite of that the tests can be considered as indicative only, since none of them was able to simulate the same load conditions, as in the mouth.

We consider the application of 7000 implants made of nano-structured titanium with a diameter of 2.4 mm to be the concrete result of long-term tests. At present not a single case of rupture or breakage of this nano-implant is known. Therefore, it can be stated that the implant with the diameter of 2.4 mm made of nTi with U.T.S. = 1250MPa is sufficiently safe for use as a dental implant. The calculations and experimental results show that at use of already available nano-structured titanium with U.T.S. of 1330 MPa - it is possible to securely reduce the diameter of the implant down to 2.0 mm.

Assumption 2

Setting of maximal tooth loading:

Authors, see for example reference [1], determined at measurement *in vivo* the maximum vertical load on the tooth of 120-150 N. At 15° deflection from the vertical axis this produced the force in the horizontal direction of max. 40 N. Similar load values are used by authors modelling tooth load, see e.g. the paper [2] - vertical load of 170 N, in the paper [3] 150 N under the angle of 7°, in the paper [4] 100 N under the angle of 45° in respect to the vertical axis of the tooth, paper [5] 100-170 N under different angles. According to the paper [5] the maximum load of tooth, at the point of transition of the crown to the root, makes then 125 MPa.

For the development of a new implant we set the lower limit of the load of the implant to the minimum value of 500N with the minus tolerance of approx. 30N.

Literature:

[1] RICHTER, Ernst. J. In Vivo vertical Forces on Implants. *Int J Oral Maxillofac Implants.*. 1995, 10, 1, s. 51-57. Available also at : http://quintpub.com/journals/omi/.ISSN 1942-4434 (on line)

[2] GOEL, Vijay K., et al. Stresses at the dentinoenamel junction of human teeth—A finite element investigation. *The Journal of Prosthetic Dentistry*. 1991, Vol. 66, Iss. 4, s. 451-459. Available also at: www.prosdent.org.

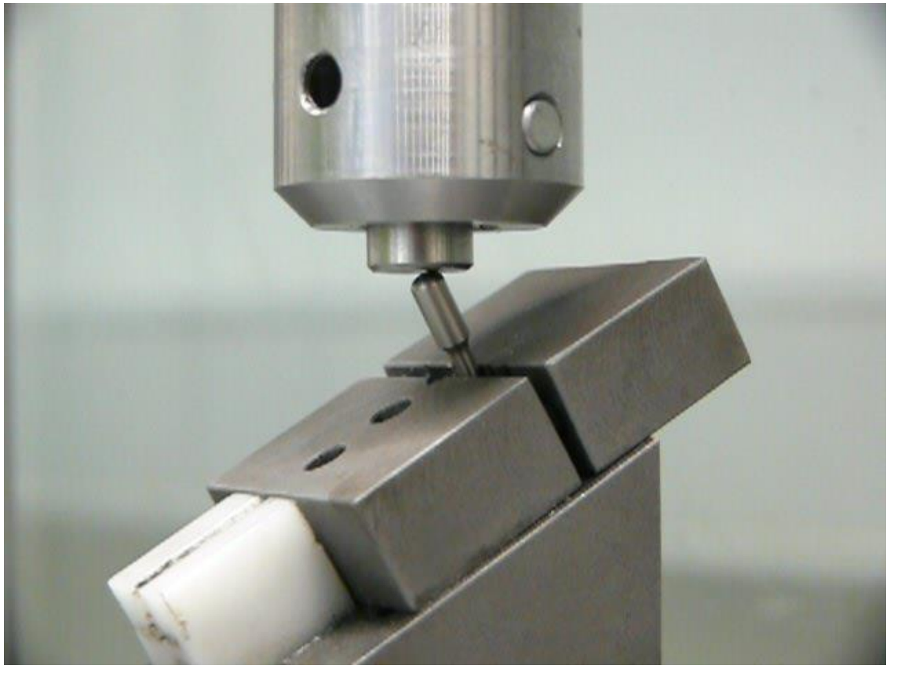
[3] ZOR, Mehmet; AKSOY, Sami. Stress analysis around dental implant in human mandible. *Mathematical and Computational Applications*. 1998, Vol. 3, No. 2, s. 83-91. Available also at: www.mcajournal.org/volume3/vol3no2p83.pdf. ISSN 1300686X.

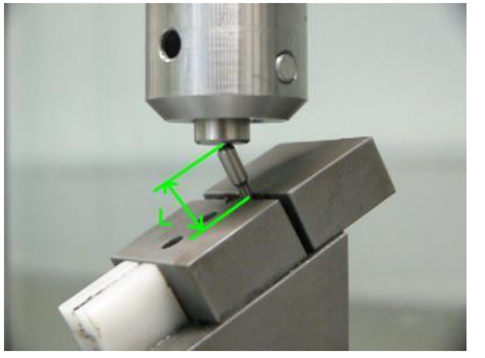
[4] AMARANTE, Martha Vasconcellos, et al. Virtual Analysis of Stresses in Human Teeth Restored with Esthetic Posts. *Materials Research*. 2008, Vol. 11, No. 4, s. 459-463. Available also at: www.scielo.br/pdf/mr/v11n4/14.pdf . ISSN 1516-1439.

[5] QIONG Li, A*n expert system for stress analysis of human teeth*. Nashville, Tennessee, USA, 2009. 82 s. Master thesIss. Faculty of the Graduate School of Vanderbilt University. Available at: www.openthesIss.org/documents/Expert-system-stress-analysis-human-368989.html> .

- Within the framework of the ViNaT project a new nano-titanium with enhanced strength of 1330 MPa was produced under direction of prof. R. Z. Valiev et al. by NanoMeT Ltd. by techniques ECAP-Conform and drawing. Enhanced strength of the new nTi allowed development of new nano-structured dental implant.

Cyclic fatigue tests



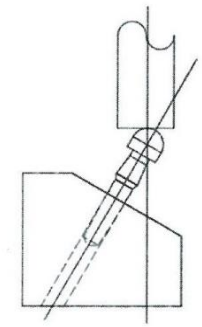


The samples were tested in two diameters of 2.04 and 2.44 mm.
The diameter was clamped at an angle of 30 ° into the testing vice. According to the standard EN ISO 14801 the sample should be loaded with 400 N (40 kg). The test started with the sample with diameter of 2.04 mm. Action of the stipulated pressure leads to irreversible bending of the sample. The pressure was then gradually reduced down to 105 N (10.5 kg).

Samples for cyclic loading

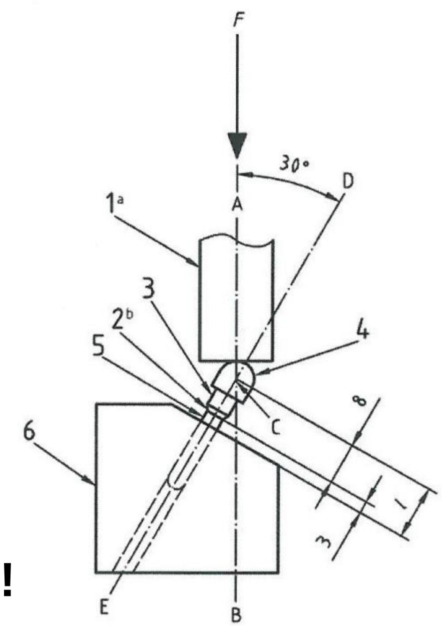
Inspired by the standard EN ISO/FDIS 14801/2007-11
This standard is not mandatory for manufacturers of dental implants

Samples before testing

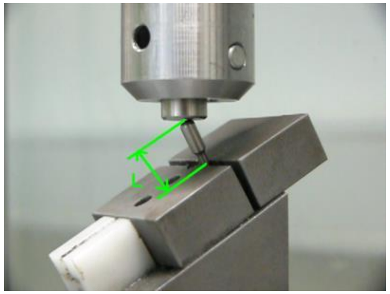


Sample with dia 2.44 mm after testing

EN ISO/FDIS 14801
F>2Hz – 5 mil. cycles
F ≤2Hz – 2mil. cycles
F_{max} = 410N
α=30º
Diameter is not defined!



Results of cyclic testing

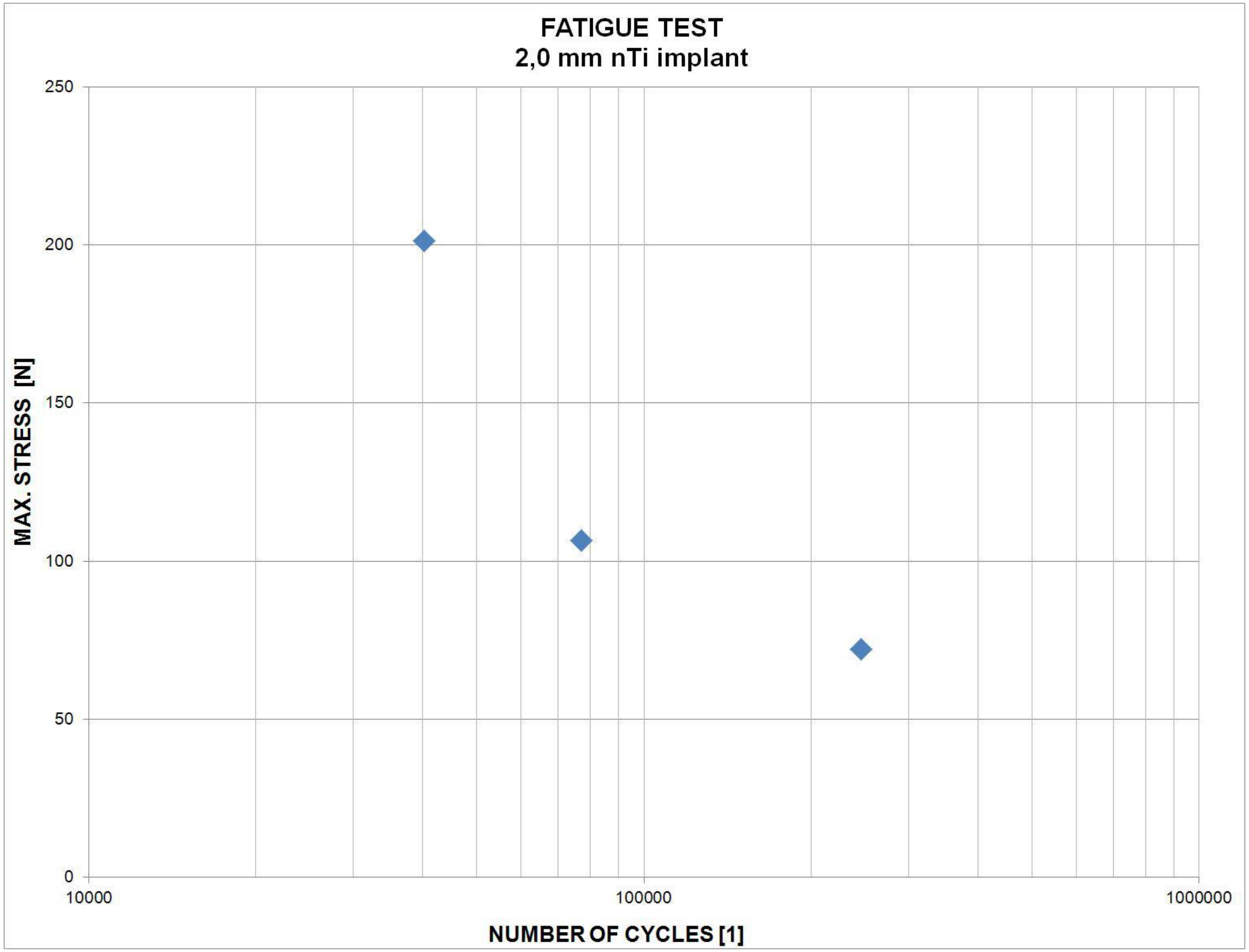


Samples Nos.1-4, dia 2.0Xmm- nTi U.T.S.=1330MPa
Samples Nos. 6.1-9, dia 2.4Xmm – nTi U.T.S.=1250MPa
Total duration of all tests : 51.5 days

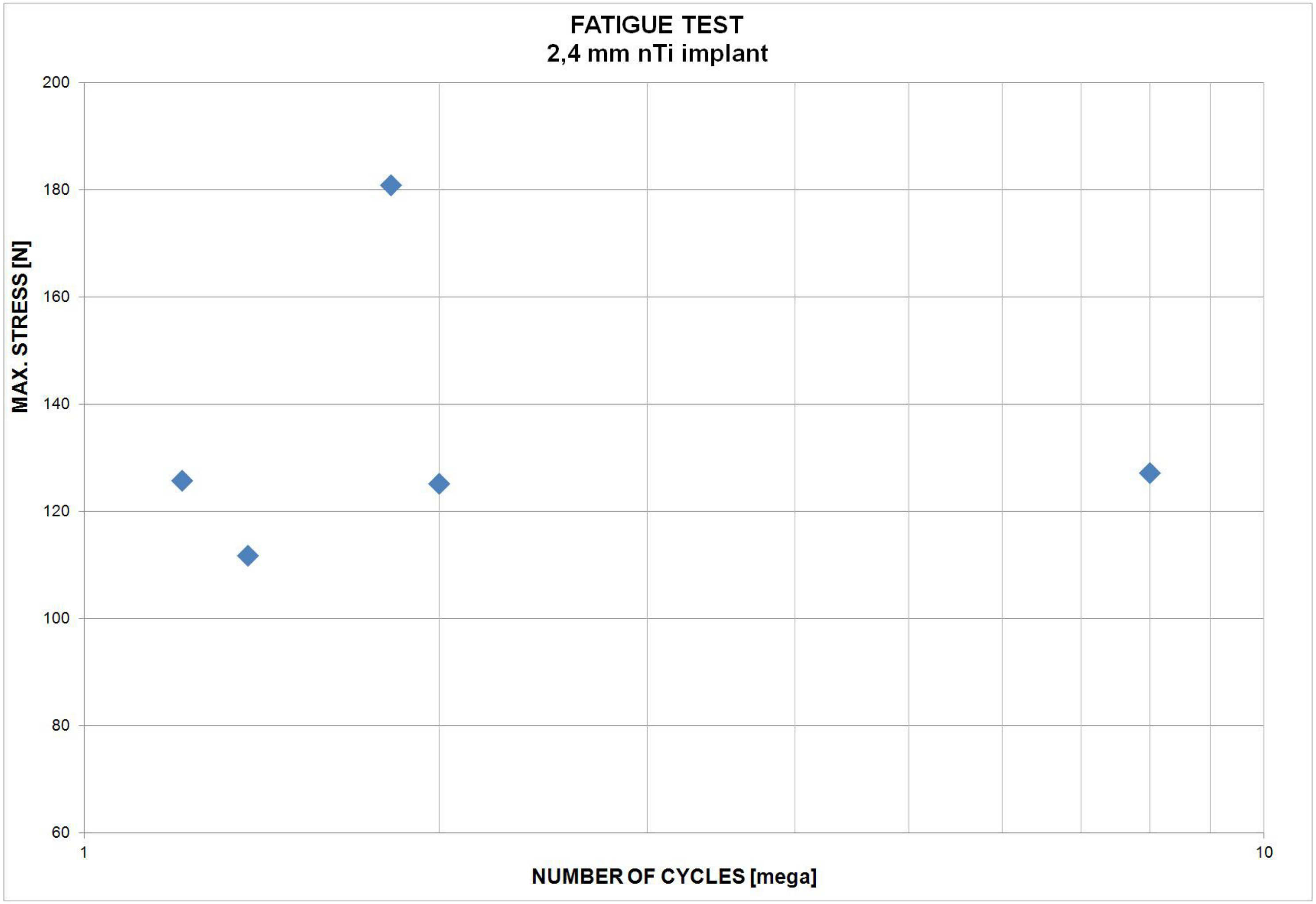
No.	Diameter (mm)	Maximum test force (N)	Number of cycles	Test time (s)	Location L (mm)	Situation
1.	2.04	400.0	**1**	1	12.43	Bent
2.	2.04	300.0	**236**	72	12.46	Broken
3.	2.03	201.3	**40 210**	16 801	12.45	Broken
4.	2.04	106.5	**77 227**	31 139	12.45	Broken
5.	2.44	111.8	**1 377 781**	440 417	12.38	Broken
6.1	2.44	127.2	**8 000 000**	2 400 005	12.44	OK
6.2	2.44	213.0	**185 052**	55 572	12.44	Broken
7.	2.43	180.8	**1 819 448**	545 836	12.43	Broken
8.	2.44	125.2	**2 000 000**	600 006	12.53	OK
9.	2.45	125.7	**1 212 466**	363 775	12.,48	Broken

The testing was performed by the company Dentamechanik s.r.o., České Budějovice, Czech Republic

Real Fatigue Results

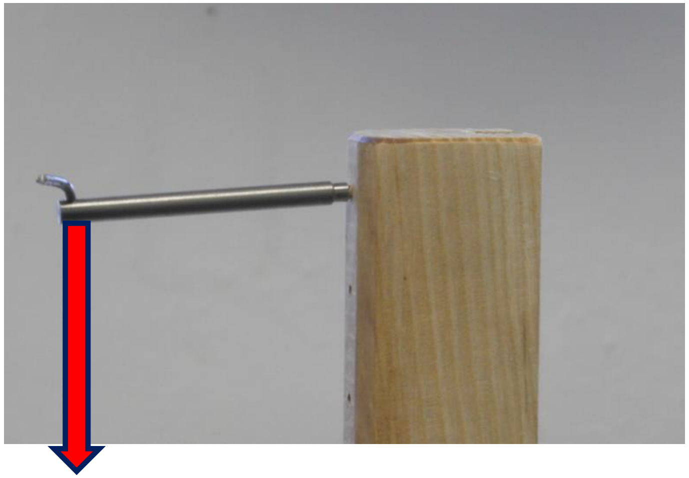


Real Fatigue Results

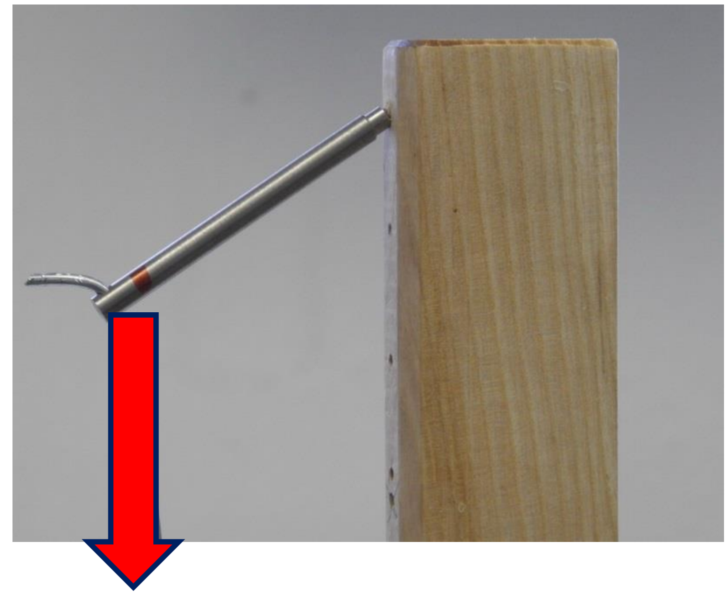


Indicative bending tests

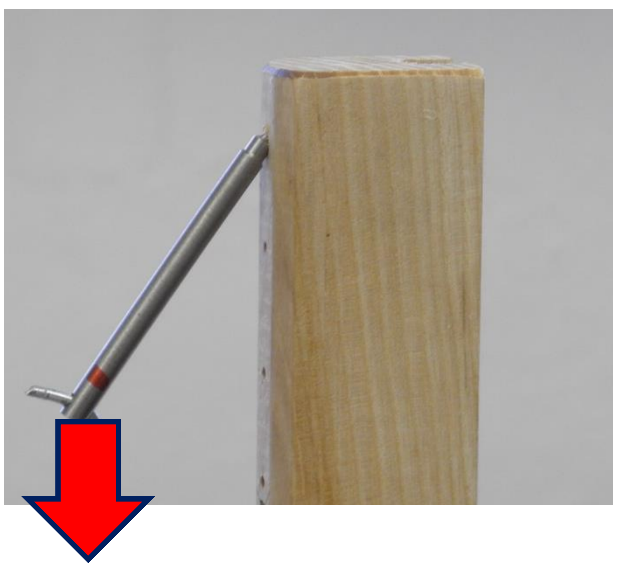
1. Start of test – load of 800g



2. Load of 6 000g

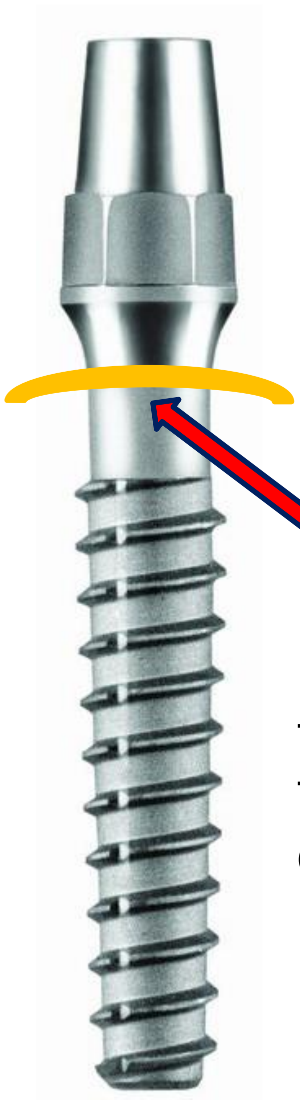


3. Load of 10 000 g



Intra-osseous part of the sample is identical with the implant of the given diameter. The samples were loaded with ballast weight to rupture. All the samples were broken in the area of the thinnest diameter. The bone was simulated by a dry ash wood, which corresponds to the bone density D1.

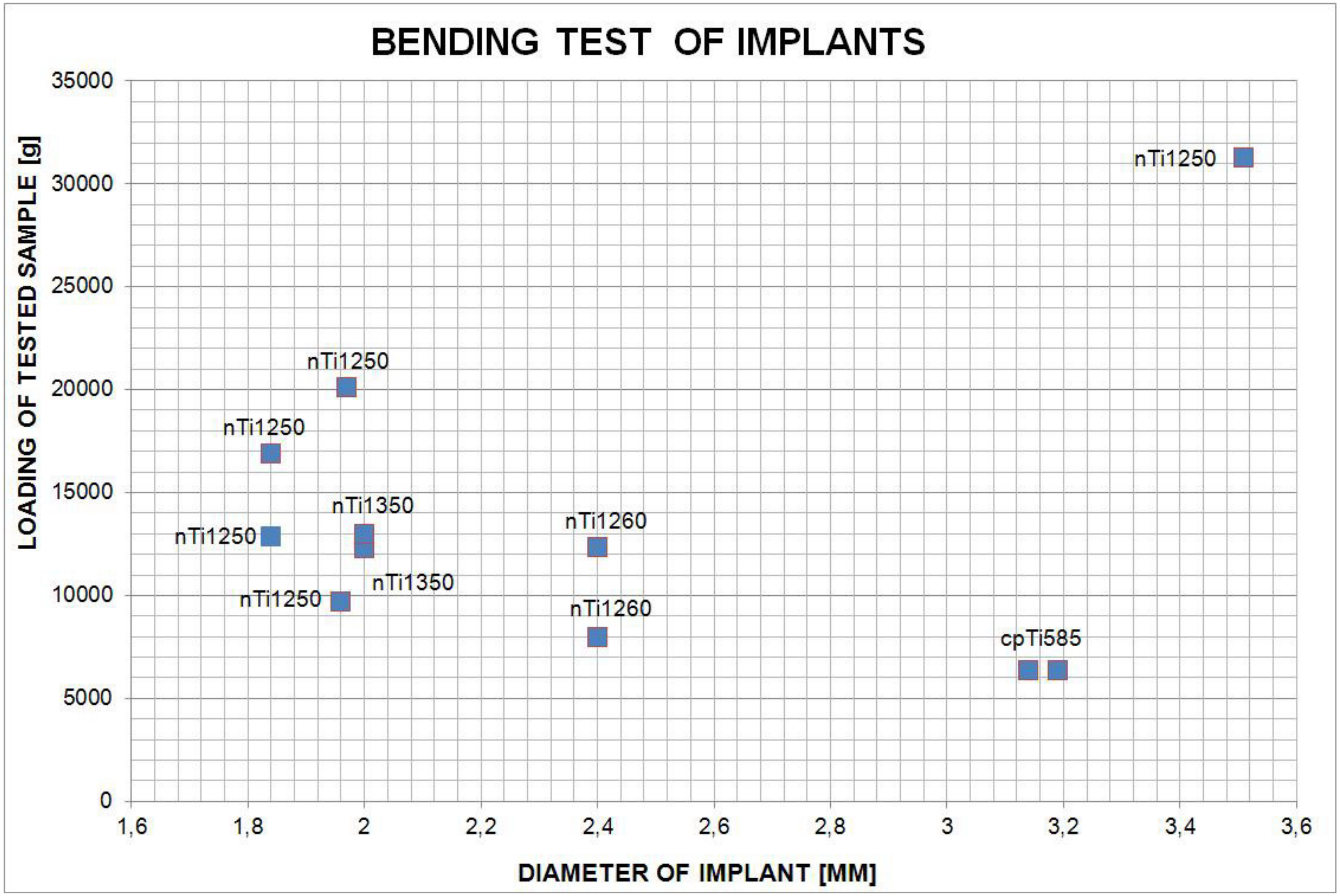
Broken samples made of nTi

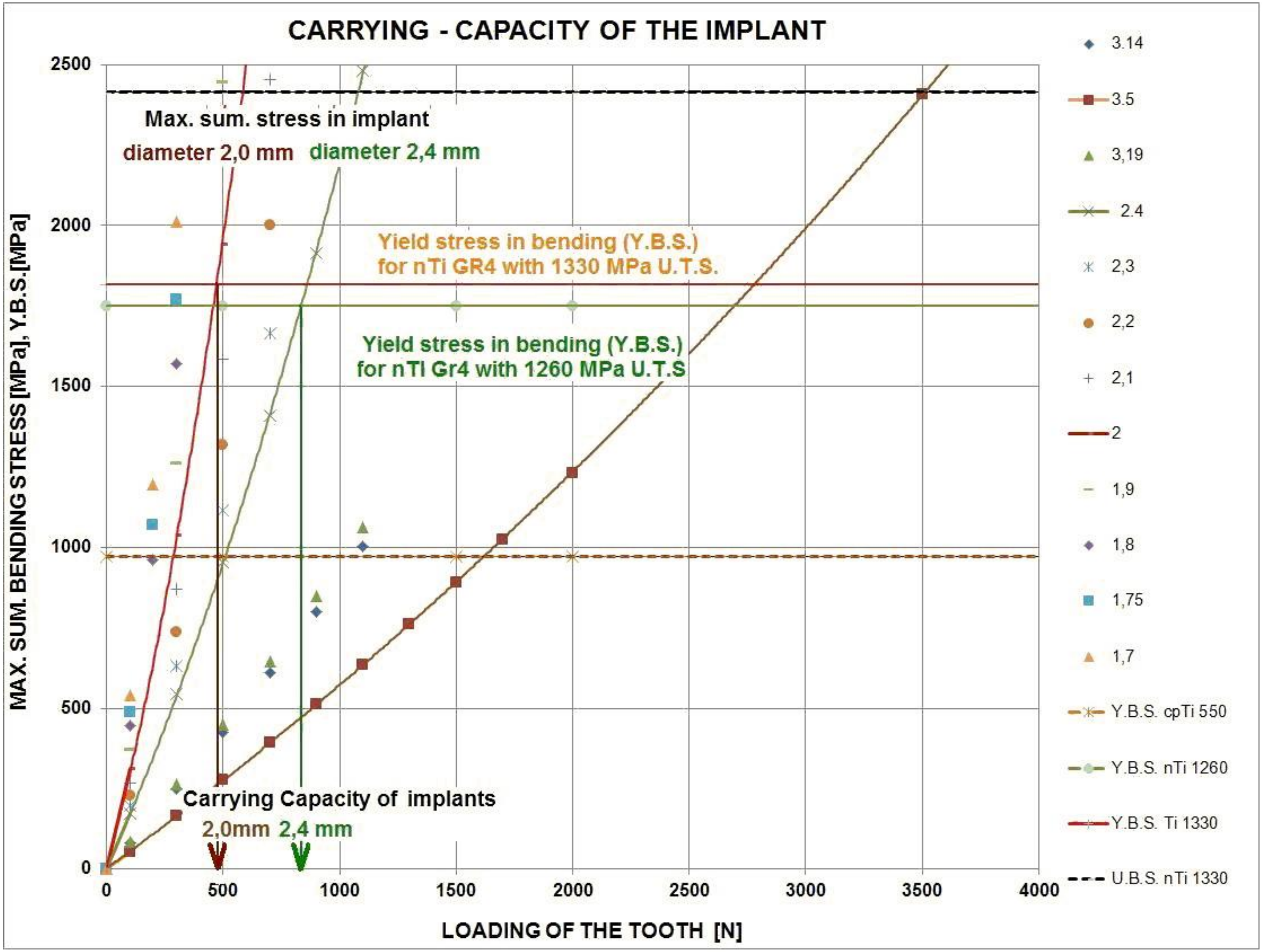


Detail of fracture

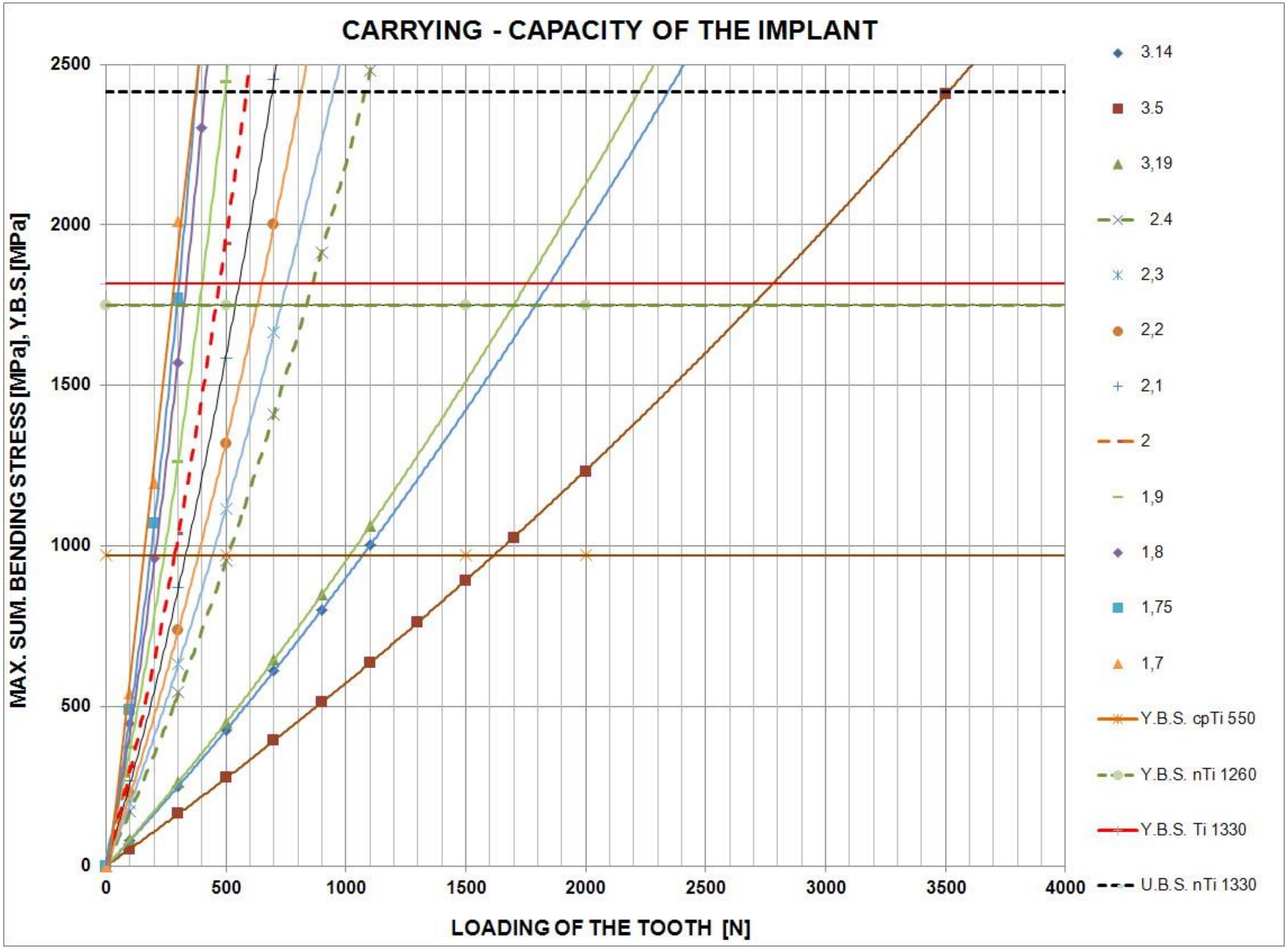
The point, where all ruptures took place.
The rupture is situated at the place
of compact bone.

Results of Bending Tests





CARRYING - CAPACITY OF THE IMPLANT
MAX. SUM. BENDING STRESS [MPa], Y.B.S.[MPa]
LOADING OF THE TOOTH [N]
Max. sum. stress in implant
diameter 2,0 mm
diameter 2,4 mm
Yield stress in bending (Y.B.S.)
for nTi GR4 with 1330 MPa U.T.S.
Yield stress in bending (Y.B.S.)
for nTI Gr4 with 1260 MPa U.T.S
Carrying Capacity of implants
2,0mm
2,4 mm
0
500
1000
1500
2000
2500
0
500
1000
1500
2000
2500
3000
3500
4000
3.14
3.5
3,19
2.4
2,3
2,2
2,1
2
1,9
1,8
1,75
1,7
Y.B.S. cpTi 550
Y.B.S. nTi 1260
Y.B.S. Ti 1330
U.B.S. nTi 1330



CARRYING - CAPACITY OF THE IMPLANT
MAX. SUM. BENDING STRESS [MPa], Y.B.S.[MPa]
LOADING OF THE TOOTH [N]
0
500
1000
1500
2000
2500
3000
3500
4000
3.14
3.5
3,19
2.4
2,3
2,2
2,1
2
1,9
1,8
1,75
1,7
Y.B.S. cpTi 550
Y.B.S. nTi 1260
Y.B.S. Ti 1330
U.B.S. nTi 1330

Prototype of the implant

- Material: nano-structured titanium Grade 4
- Titanium strength: U.T.S.= 1330 MPa
- Implant diameter: 2.0 mm
- Total length: 20.1 mm
- Length of intra-osseal part: 12 mm
- Surface of intra-osseal part: Etched
- Surface of gingival part: Polished
- Assumed load-bearing capacity: 480 N
- Indications: single tooth or bridge
  at the frontal part

Properties of Ti Gr4 produced by ECAP-C and drawing

Ti Grade 4	UTS, MPa	YS, MPa	δ, %
Standard	780	600	29
ECAP-C +Drawing	1250	1150	12
NEW ECAP-C +Drawing	**1330**	**1145**	**11**

Dia 3.5

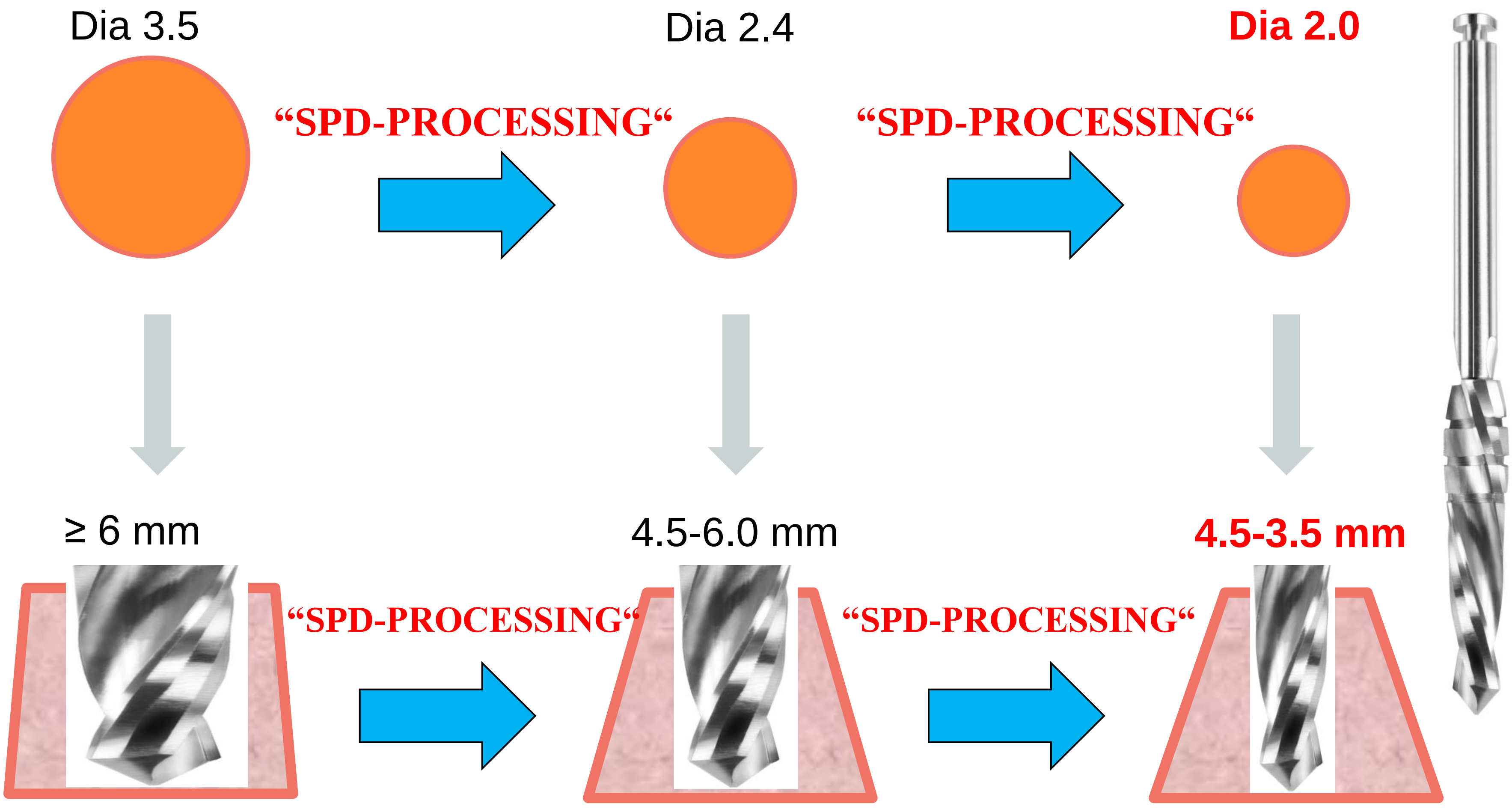
SPD-PROCESSING

Dia 2.4

SPD-PROCESSING

NEW
Dia 2.0

Cross-section of the bone´s hole for implant



Cross-section of the bone´s width for implant

Benefits enabled by ECAP CONFORM

- 1. Possibility to treat the patients by use of implants with the alveol width below 4.5 mm
- 2. Simplification of surgery action
- 3. Smaller wound facilitates better success of implant healing
- 4. Purity of the implanted titanium is 99% without allergising and toxic elements
- 5. Faster treatment of patients
- 6. Low price

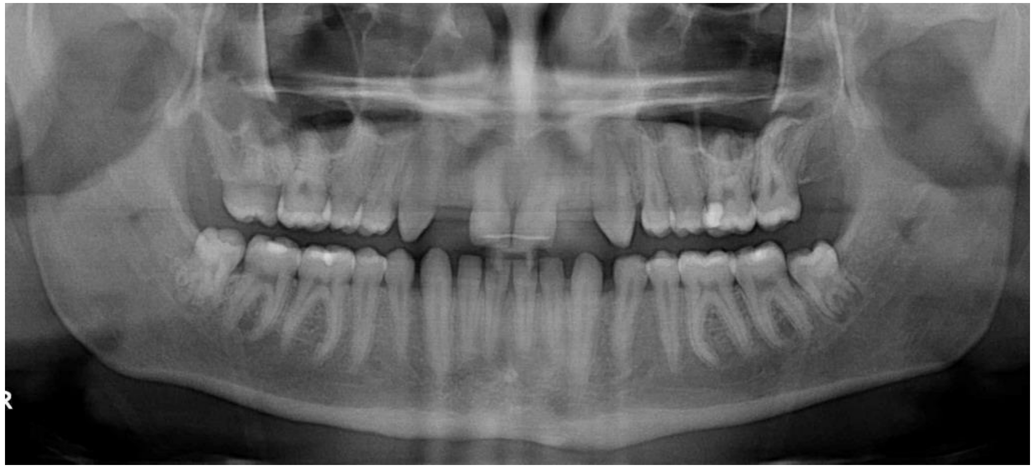
Application of The Prototype of Dental implant Vinat

The prototype of an implant with diameter of 2.0 mm (Vinat) was applied to a 18-year old patient (by stomato-surgeon MUDr. M. Brückner), who was after long orthodontic treatment and who gave his consent with the application of this prototype of implant. The patient did not have a basis of his own natural teeth in the areas 12 and 22. After examination and after investigation of several radiographs the surgeon decided that in the area 22 (the second tooth on the top left) there was no suitable bone and that he would not implant into this locality an implant with the diameter of 2.4mm due to lack of transverse dimensions of the bone.

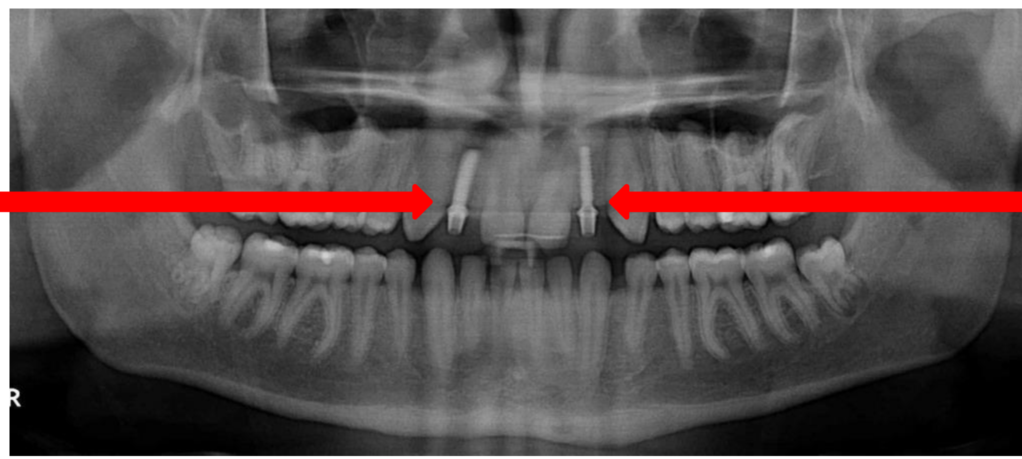
In the end the nanoimplant Vinat dia 2.0 mm was inserted!

X-RAYS

X-RAY before implantation



X-RAY after implantation



Dia 2.4 mm

Dia 2.0 mm

Photo: MUDr. M. Brückner, Dental Surgery B&B dent, Frýdek Místek, Czech Republic

Radiovisiography

Photo: MUDr. M. Brückner, Dental Surgery B&B dent,
Frýdek Místek, Czech Republic

After insertion of 2.0 mm implant

Photo of the upper jaw with the applied prototype of the implant Vinat

After insertion of 2.0 mm and 2.4 mm implants

Photo of the upper jaw with the applied prototype of the implant Vinat
- on the right side of the picture dia 2.0 mm
- on the left on the picture dia 2.4 mm

Immediately loaded implants

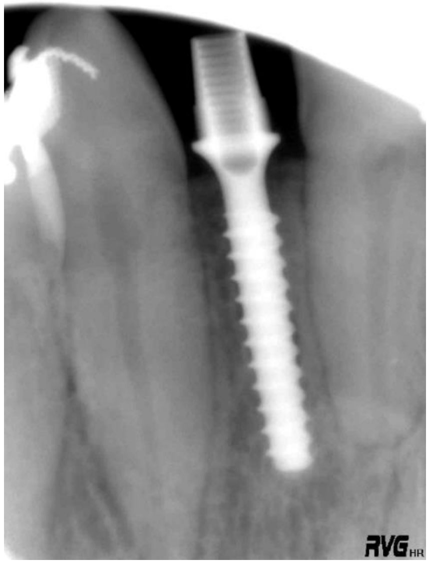
Provisional crowns fixed after 2 hours after surgical procedure

Final metal-ceramic crowns

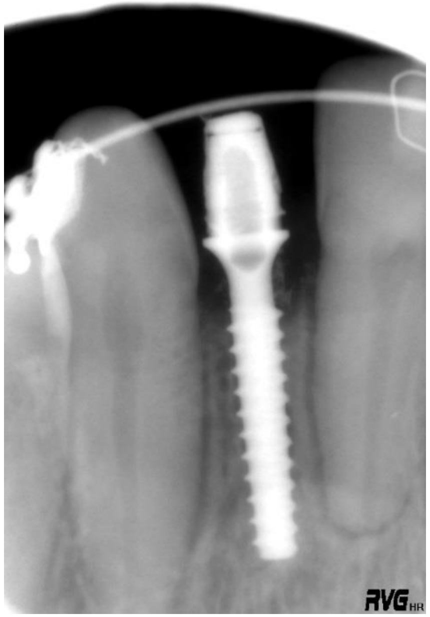
Applied 6 weeks after application of implants

Another example of application of the implant ViNaT

State before application



Applied implant



Implant with provisional crown

A woman aged 42 years, after orthodontic treatment, narrow bone and little space between teeth.
The teeth braces can be seen in the picture.

Photo: MUDr. M. Brückner, Dental Surgery B&B dent,
Frýdek Místek, Czech Republic

Thank you for your attention

At this last meeting of the project ViNaT I would like to thank all participants in this project for their collaboration. My special thanks go to these two friends:

Special thanks to professor Ruslan Z. Valiev and Dr. Leon Mishnaevsky

DTU
FIAS Frankfurt Institute for Advanced Studies
instituto iMdea
KATHOLIEKE UNIVERSITEIT LEUVEN
Timplant dental implants
МИСиС
ISPMS SB RAS
GOETHE UNIVERSITÄT FRANKFURT AM MAIN
TECHNION Israel Institute of Technology
VINF
УГАТУ

Thank You All