

# Dental implants of innovative design: comparative evaluation of the instrumental preparation techniques and their impact on bone tissues

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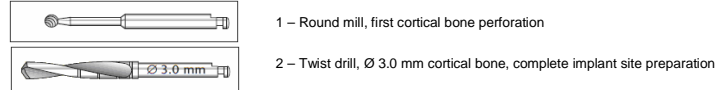
Dental implants became more and more important in dentistry since the beginning of the 80's and their use in this ambit has revolutionized dental treatment modalities with excellent results. Several aspect had to be considered to reach the long-term success of the dental implant itself: stability of implant-abutment and implant-bone surfaces and primary stability are only a few part of these. The longevity of the implant is extremely correlated to the osseointegration process, that generally takes place in the peri-implant region in the first three to six month after implantation, in order to confer stability to the implant-bone system. For these reasons the study of the different site preparations, devices and their effects on the bone in which the implant will be placed assumes a critical importance for the complete understanding and improvement of the insertions procedures.

## Materials & Methods

In order to evaluate the impact of the preparation techniques on bone tissues, implant sites surfaces were analysed by Scanning Electron Microscope (SEM), FT-IR and SEM-EDS, seeking traces due to instrumental preparations. Therefore an AFM analysis was conducted to check traces of biological material on the instruments.

### STATE OF ART, DRILL TECHNIQUE

Portions of spare ribs have been fleeced in order to remove the periosteum, then these bone sections have been pierced. The classic drill technique first consists in removing cortical bone using a spherical mill. Then the mill shape is changed, in order to complete the site preparation by a Twist drill, that pierced the bone in all the site length. The whole process is performed in the presence of a constant manual irrigation by saline. The strong invasive features of this process moved the attention on different site preparation solutions.



### INNOVATIVE TECHNIQUE, MECTRON PIEZOSURGERY

The MECTRON Piezosurgery III enable piezoelectric bone surgery adapting ultrasound movement for bone cutting. This technique allows an extreme surgical precision using micrometric cutting, which is selective with no damage for soft tissues.

- 1 - OP5: Bone perforation, initial pilot osteotomy
- 2 - IM2P: Implant site preparation, pilot osteotomy on surrounding cortical bone
- 3 - OP6A: Implant site preparation, complete the implant site



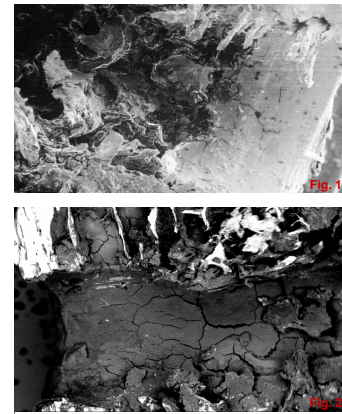
The innovative instrument automatically provides for the irrigation of the surgical area during the implant site preparation.

## Scanning Electron Microscope

### DRILL

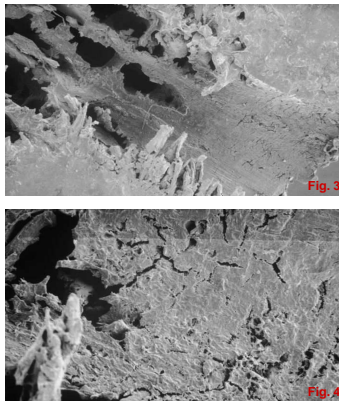
The trabecular structures are no more recognizable because of the deposition of a mixture of biological components on the implant site surface, called *bone jam*. Temperature and rotating motion due to drill site preparation favour the filling of the trabecular bone cavities (Fig. 1).

Several linear and interconnected micro-cracks are evident on the cortical bone (Fig. 2).



### PIEZOSURGERY

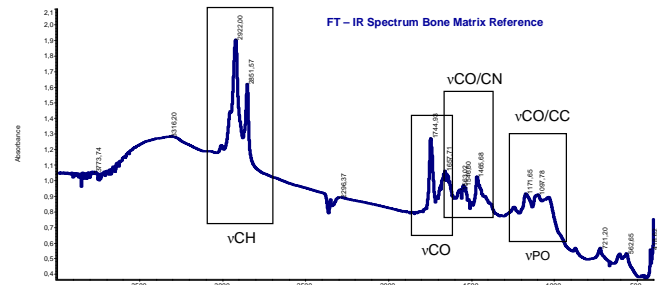
At first sight is evident how the implant surfaces are much cleaner than the drilled ones. The Haversian canals and the whole trabecular structure is respected by the piercing treatment and with no sign of deposition of biological material after the site preparation (Fig. 3). Even the cortical bone shows to be more respected; bone cracks are less interconnected with each other and their shape is different, neither linear nor orientated (Fig. 4).



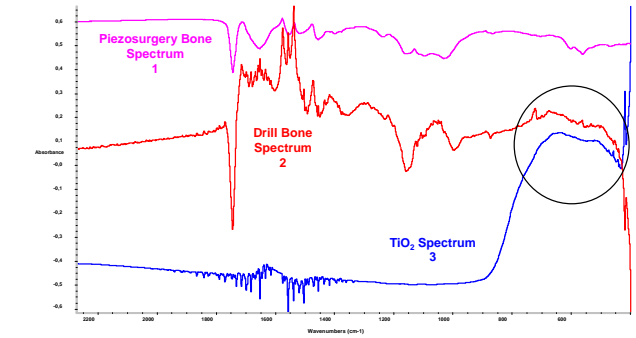
## Fourier Transform Infrared Spectroscopy

The spectroscopic technique allows the absorption regions originated by molecular vibrational modes from which it's possible to create a FT-IR spectrum. From this spectrum we can highlight the different resonance frequencies and the respective vibrational structures (Spectrum Bone Matrix Reference).

In this way the spectroscopic technique is used to search possible traces of instrumental processes on the implant site surfaces. Spectra 1 and 2 are obtained by subtracting the Spectrum Bone Matrix Reference from the spectrum of bone implant site produced by Piezosurgery and drill respectively. Then those spectra are compared with a TiO<sub>2</sub> spectrum.

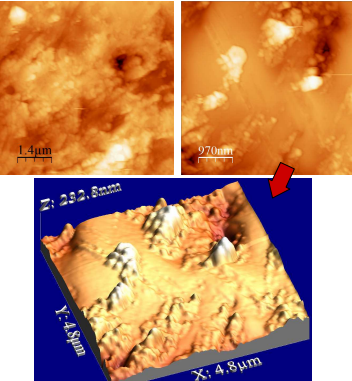


Spectrum 2, representing the drilled bone, shows at the low frequencies (700-500 cm<sup>-1</sup>) a very similar behaviour to Titanium Oxide TiO<sub>2</sub> Spectrum (Spectrum 3). Contrarily in the Spectrum 1 related to the Piezoelectric bone site such an effect does not appear, suggesting that the metallic traces are more significant on implant sites created by classic technique by mill.



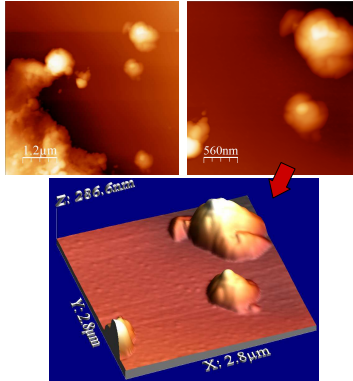
## AFM Analysis

### DRILL



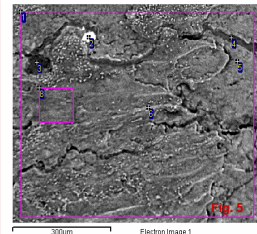
The drill insert shows hard depositions of biological material, due to working in site preparation, on its regular surface. These several irregular deposition show the strong interaction between the bone tissues and the drill in this way of piercing.

### PIEZOSURGERY



The deposition of biological material is highlighted on the surface but not so spread and evident as before. It can be noticed a lesser degree of absorption of material on the Piezosurgery insert.

## SEM-EDS Analysis



Spectrum	O	Na	Mg	Al	Si	P	S	K	Ca	Total
1	0.55		0.02			0.08			0.04	0.70
2	0.64			0.03		0.06			0.10	0.83
3	0.14					0.02			0.02	0.18
4	2.76				0.13				0.18	3.06
5	4.63	0.24				0.99	0.33	0.50	0.10	6.79
6	0.50			0.01		0.03			0.07	0.61
7	6.84	0.33	0.16			1.76	0.56	0.71	0.21	10.57
8	0.13			0.02		0.01			0.04	0.20
Max.	6.84	0.33	0.16	0.03	0.13	1.76	0.56	0.71	0.21	
Min.	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	

The bone tissue surface obtained by mill shows several linearized micro cracks strongly interconnected to each other (Fig. 5), that may cause fractures in the implant site surface and carry to system fail. The SEM-EDS analysis revealed in some sites traces of Magnesium and Aluminium.

## CONCLUSIONS

The analysis carried out using Scanning Electron Microscope, Fourier Transform Infrared Spectroscopy and SEM EDS have led up to significant results.

First the quality of sites made by MECTRON Piezosurgery has been significantly better than the milled ones, as a matter of fact the innovative piezoelectric cutting technique demonstrates to be more sensible in interactions with bone tissues. This behaviour is supported by the SEM images that show how the trabecular bone structures are intact and not polluted by biological material of working.

On the other hand the classic piercing technique is more invasive and mines the osseointegration processes by deposition of bone jam on the implant site surface. SEM EDS and in particular FT-IR analysis revealed metallic traces on drill implant site surfaces.

Not interconnected micro cracks appeared on the cortical regions. Dramatic differences can be noticed in classic piercing technique, that is hugely aggressive and produces several and more relevant cracks.

## References

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## ACKNOWLEDGMENTS

The authors thank to Ing.M.Ferrari, CNR- IENI of Genoa for AFM tests carried out on dental implants, and Dott.P.Riani, DCCI University of Genoa for SEM-EDS tests carried out on animal bone.