

Evaluation of Bone And Hard Biomaterials using Microcomputed Tomographic Technique

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Introduction

The aim of the present study is to evaluate bone biopsies from the grafted sinuses of three patients. Biopsies from the patients are evaluated with standard histomorphometry and micro-CT. The values obtained with the two different techniques are compared to verify the reliability of the micro-CT technique as a new way to the evaluate bone samples containing hard biomaterials.

Methods and Materials

Three patients received, in three maxillary sinuses, a bone graft with a bioactive glass bone substitute (Biogran®) mixed with autogenous bone and autogenous gel of Platelet Rich Plasma (PRP). Bone biopsies were retrieved after 5, 6 and 15 months of healing for analysis, with microCT and histology .

Results

Sample 1



Fig 1 3D micro-CT reconstruction of a cylindric biopsy retrieved from a sinus grafted with Biogran after 5 months of healing. This sample shows a representation of the bone trabeculae.

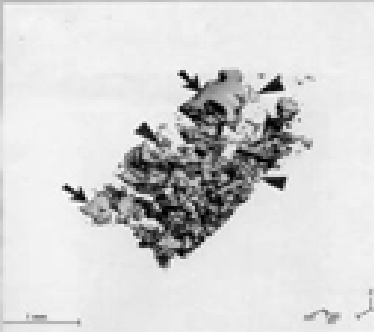


Fig 2 3D micro-CT image showing the spatial distribution of the graft in the biopsy. In this image, two different shapes are evident: particles (black arrowheads), probably Biogran granules, often broken into small parts, and particles (black arrows) that closely resemble the autogenous bone chips of the graft.



Fig 3 2D micro-CT analysis It is possible to observe three main radiographic densities. A very high density with a granular shape could presumably represent granules of Biogran (arrowheads). It is also possible to see dark gray structures with a morphology similar to that of thin bone trabeculae (arrows). A third structure is visible, with a radiodensity that is intermediate between the bioglass and the bone trabeculae, that could represent the autologous bone chips (asterisks).



Fig 4 Histologic overview. Thin bone trabeculae are visible (blue staining), containing many large and rounded osteocytic lacunae. Small and crumbled pieces of Biogran are found between the bone and marrow tissues (toluidine blue).

Sample 2

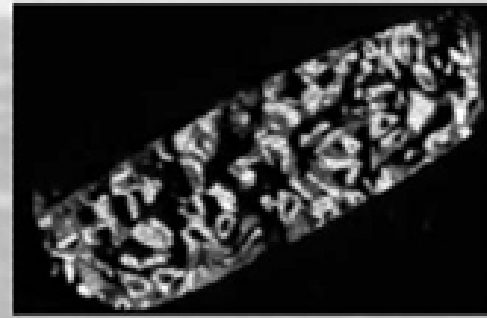


Fig 5 A dense bone was found composed of thick trabeculae very well connected to each other (dark gray). Dense particles similar to granules of Biogran (light gray), mostly encased within mineralized bone, are evident (arrowheads). The particles are mostly broken into pieces or excavated into the center.

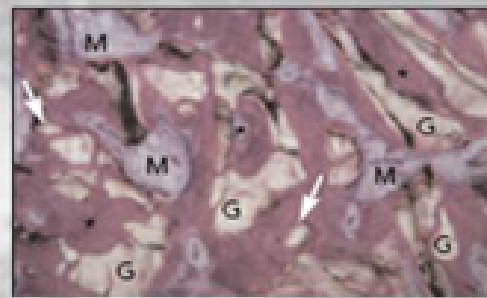


Fig 6 Large amounts of bioglass particles were found encased in the bone matrix, mostly osseointegrated. The Biogran particles are disrupted in small pieces (arrows) or hugely excavated in the center and filled by bone (asterisks) (basic fuchsin and toluidine blue). B = bone; G = granules of Biogran; M = soft marrow tissue.

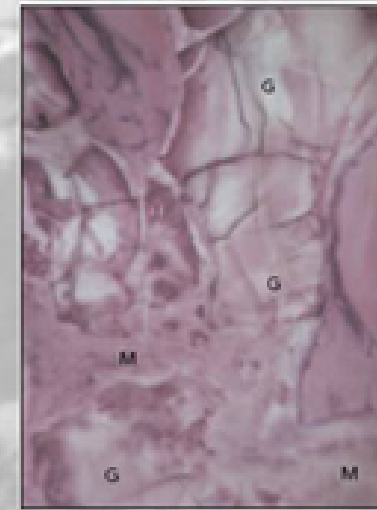


Fig 7 In some places, the surfaces of the Biogran particles (G) exposed to the soft marrow tissue (M) are covered by macrophages digesting small parts of the glass (basic fuchsin and toluidine blue).

	Healing time (mo.)	PRP in graft?	TBV/TV (%)		BV/TV (%)		GV/TV (%)		BGC/TGS (%)
			μCT	Histo	μCT	Histo	μCT	Histo	Histo
Sample 1	5	Yes	40	42.52	29	37.53	11	4.99	25.79
Sample 2	15	No	68	65.70	34	49.71	34	15.99	60.17
Sample 3	6	Yes	64	58.85	36	41.32	28	17.53	45.24
Mean	—	—	57.33	55.69	33	42.85	24.33	12.84	43.73
SD	—	—	15.14	12.92	3.60	6.23	11.93	6.84	17.24

Table 1 TBV/TV = total volume; BV/TV = vital bone volume; GV/TV = graft volume; BGC/TGS = bone/graft contact.

	TbN (1/mm)		TbTh (μm)		TbSp (μm)	
	μCT	Histo	μCT	Histo	μCT	Histo
Sample 1	6.05	2.54	70	167.38	100	226.24
Sample 2	5.27	2.91	130	225.83	60	117.88
Sample 3	6.45	4.30	100	136.86	60	95.69
Mean	5.92	3.25	100	176.69	73.33	146.60
SD	0.60	0.92	30	45.21	23.09	69.85

Table 2 TbN = trabecular number; TbTh = trabecular thickness; TbSp = trabecular separation.

Discussion

It is important to clearly analyze the 3D architecture of the regenerated bone after sinus grafting and its relationship with its mechanical competence to better clarify the healing time of the graft and the implants and to determine what loading conditions to apply.

The ultimate goal of any bone measurement in patients is to estimate bone strength. Because most regenerative procedures are performed to obtain strong tissue to support implant placement, it is important to precisely quantify bone micro architecture with a 3D technique, such as micro-CT 3D analysis. Moreover, under histologic analysis we could not distinguish between newly formed bone and grafted autologous bone because of the difficulty in clearly identifying the latter.

Micro-CT techniques have not been used to perform a 3D quantitative evaluation of bone biopsies containing hard biomaterials from the maxillary sinus. To validate micro-CT measurements, it is very important to compare the data obtained by standard histomorphometry to the data obtained using micro-CT in the same biopsy sample. This is possible because micro-CT is a non-destructive technique that allows subsequent histologic analysis. The histologic examination showed the same differences between samples, but the connectivity values obtained from the micro-CT were quite different from the corresponding histologic values. This may be a result of the 2D limitation of the histologic analysis for parameters that reflect a structural spatial organization, as do the connectivity indexes.

Conclusion

Micro-CT is shown to be a fast, nondestructive procedure that allowed measurement of trabecular and compact bone and of the radiopaque grafting materials in unprocessed biopsies as well as an automatic determination of 3D structural morphometric indices. Micro-CT might help us to investigate the relative importance of bone architecture as a better index of bone strength, especially when used in combination with histologic study and evaluations the healing of narrow implants with a rough surface .

References and Acknowledgments

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