VAPOR DEPOSITED CARBON COATED TOOTH ROOT REPLICAS

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Successful dental implants are dependent on both design and materials considerations. The aim is to achieve long term stability and retention with the implant in function. In the work reported here, tooth root replicas were made of cast vitallium and coated with a thin impermeable layer of vacuum vapor deposited carbon. The design advantage of a tooth root replica is that masticatory loads are distributed through the supporting alveolar bone of the jaw much as they are in normal dentition. One of several common causes for the failure of various implant designs is excessive loading of a small alveolar area, i.e., stresses are not distributed adequately [1, 2]. The materials used have extensive implant histories and their biocompatibilities are well known. The principal advantage of the carbon coating is the enhancement of the permucosal surface where the tooth, its root seated in bone, must penetrate the mucosa into the mouth. This area generally contributes to implant failure because of lack of a seal between implant and mucosa. Inflammation of the mucosa, the collection of debris on the tooth cervix, or neck, and bacterial invasion disrupt the integrity of the implant and host.

Materials and Methods

Sixteen carbon coated implants were cast in vitallium, coated with carbon and implanted in 5 dogs. The implants were replicas of premolars for 10 teeth and of molars for 6 teeth. The design, shown in figure 1, incorporates the tapered root normally found in these teeth, and a large hole in the root to allow bony ingrowth from the surrounding alveolar tooth socket. The tooth cingulum was smaller than in normal teeth to decrease the length of the gingival carbon junction, yet big enough to support masticatory forces [3]. The cingulum should be smooth at the gingivocarbon junction to promote good hygiene. The implant shoulders should be of appropriate size to allow them to be located below the alveolar bone surface (figure 1).

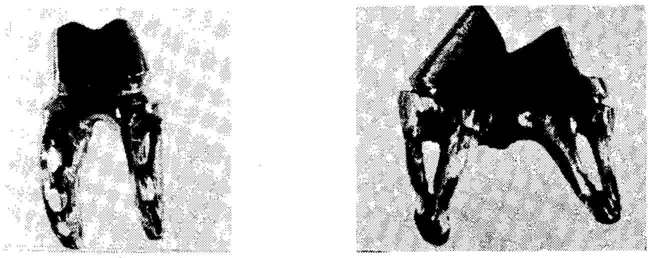

Fig. 1: TOOTH ROOT REPLICAS for human (L) and dog (R).

For comparison, two alumina oxide (Al_2O_3) coated titanium implants were placed in the opposite side of the jaw to evaluate the permucosal acceptance of the two different coatings. The Al_2O_3 was applied by Plasma-jet to form a chemical bond between ceramic and metal.

Additionally, four LTI-Si carbon endosteal blades were placed in the mandibles of two dogs, adjacent to carbon replicas in one animal, and on the opposite side in the other. This was to evaluate the bone-carbon interface of the two different implant designs.

The tooth root replicas were prepared in two ways. Initially, the replicas were made from impressions taken of tooth extraction sites and the implants were placed in the animals about 2 weeks after extraction. Later, the implants were replicated from impressions of corresponding mandibular teeth from other dogs of similar size and were implanted in the study animal immediately after extraction.

Metallic splints were cemented over the remaining teeth and over the implant tooth crown and circummandibular wires were placed to provide additional stabilization. Unfortunately, the circummandibular wires were intermittently loose requiring tightening or replacing. The animals were given antibiotics for 1 week following surgery. During the first 2 weeks after surgery tissues surrounding the implant posts were checked every 2 or 3 days and basic oral hygiene therapy around the implant region was performed. Thereafter each animal was evaluated every 2 weeks by radiographic examinations in order to evaluate mandibular bony behavior, and hygiene was performed. The dogs' diet was exclusively soft food, usually for the first week only. No infections developed because of implants or transmucosal or circummandibular wires as indicated by both clinical and radiographic examinations. Results: Four of the five animals were sacrificed about three months after implantation. I.V. alizarine was given one month pre-sacrifice for intravital staining. On removing the metallic splint, the implant mobility was evaluated and rated according to the lateral displacement of the implant. The gingival sulcus was also probed and the pocket depth reported in millimeters (Table I). After sacrifice, radiographs were taken of the entire mandible as well as each alveolar section containing the implants. Histological specimens were taken of the mucosa around the implant's cervix, and alveolar sections of the mandibles containing one implant per specimen. These latter have been embedded in methylmethacrylate resin and cut in sections of about 60 to 80 u. for microradiographic and histologic examinations. The results of these preliminary data, the radiographic examinations, visual observations with probing and the histology, suggest that the combination of design and materials is worthy of further study.

Conclusions

1) The mechanical stability of tooth root replicas was found to be higher than endosteal blades. Seven out of the 16 implants had no mobility and were completely firm (Table II). However, it has been shown that the blade design used for this study was less than ideal and the General Atomic Company has modified the design for the LTI-Si blade study in animals [4]. It should be noted that the looseness of the splint was a detriment to the implant. Others have now reported that it is advantageous to implant blades without splints [5]. 2) Histological sections were compatible with satisfactory biological acceptance for both carbon and alumina tooth root replicas. 3) When both carbon and alumina sprayed implants had the same degree of stability (less than .5mm of mobility) the permucosal response was comparable. There was a moderately hyperplastic epithelium with macrophages present in the perivascular connective tissue, the number present increasing with pocket depth.

It has been observed that porous tooth roots are lost with time because, as the microporous structure becomes invaded by bacteria, there is progressive resorption of the bony socket [6]. However, the shortness of the study reported here, three months, precludes us from substantiating this observation. It was clear, none the less, that the stability of tooth root replicas and the permucosal response to carbon coated implants give promise of great usefulness for this combination of design and material in dental implantology.

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COMPARISON OF TOOTH IMPLANTS IN DOGS

Dogs	Sacrificed after Implant No. of Days	Wt in kg	Time Between Extraction and Implantation	Tooth Replaced and Implant Type*	CLINICAL RESULTS: Lateral Mobility (mm) Right Mandible	Gingival Sulcus (mm) Right Mandible	Lateral Mobility (mm) Left Mandible	Gingival Sulcus (mm) Left Mandible	Tooth Replaced and Implant Type*
1 (1312)	96	27	12 days	V 3rd p.m. V lst mol.	2 1.5	3-4 3	1.5 .5	3-4 2-2.5	V 3rd p.m. T lst mol.
2 (1209)	96	38	16 days	V 3rd p.m. V 4th p.m. B lst mol.	1.5 1.5 1.5	1.5-2 2.5 2-3	1.5 0	2.5 2.5-3	B 3,4th p.m. V lst mol.
3 (1368)	82	28	0	V 3rd p.m. T lst mol.	1.5 0	1-3 1-1.5	0 0	1-2 1	V 3rd p.m. V lst mol.
4 (1376)	88	27	0	V 4th p.m. V lst mol.	1 0	1.5 1	.5 .5	1-3 0.5-2	V 4th p.m. V 4th p.m.
5 (970)	Alive, Splint removed 102 days	17	0	B 3,4 p.m. B lst mol.	1 2	5-6 >5	.5 0 0	2.3 3 1.5-3	V 3rd p.m. V 4th p.m. V lst mol.

* key: V = vacuum vapor deposited carbon root replicas (16); T = Titanium root replicas coated with Al_2O_3(2); B = LTI-Si carbon blades (4)

TABLE I

COMPARATIVE CLINICAL RESULTS IN DOGS

IMPLANTS COMPOSITION	TOOTH ROOT REPLICAS			ENDOSTEAL BLADES
	Vacuum Vapor Deposited Carbon Coated Vitallium		Al_2O_3 Sprayed Titanium	LTI - Si Carbon
	Premolars	Molars	Molars Only	
No. of Implants	10	6	2	4
LATERAL MOBILITY < .5mm	40%	83%	100%	0%
SULCUS DEPTH < 2mm	30%	66%	50%	0%

TABLE II