Long-Term Results of Implants Immediately Placed Into Extraction Sockets Grafted With β-Tricalcium Phosphate: A Retrospective Study

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Purpose: The aim of this 10 year retrospective study was to evaluate the crestal bone loss around immediate implant placed in tricalcium phosphate (TCP) grafted extraction sockets

Materials and Methods: Data were collected from files of 58 patients (33 females, 25 males, average age 54.78 years) undergoing immediate implant placement into fresh extraction socket with or without the use of TCP (Cerasorb, Curasan AG, Kleinostheim, Germany) grafting. After implant placement, horizontal gaps larger than 1.5 mm between the implant surface and the bony plate were grafted with TCP without the use of a membrane, while smaller gaps were not grafted. Two hundred fifty-four implants were inserted: 79 were placed immediately with the use of β-TCP as grafting material (group A), 175 were placed in healed extraction sites, with 61 implants placed with the use of β-TCP graft material (group B), and 114 implants were placed without any grafting material (group C). Bone loss recordings were performed using periapical radiography. Measurements were performed from the neck of the implant to level of the surrounding bone in the vertical dimension.

Results: No implant was lost during the follow-up period. Statistical analysis showed no correlation between implant placement timing (delayed or immediate), the use of bone graft, and extent of bone loss.

Conclusion: The use of TCP (Cerasorb) as a grafting material during immediate implant placement allowed no bone loss in 72.1% of the implants, which was very similar to the nongrafted cases for which implants were placed in favorable conditions.

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Immediate implant placement[1] into extraction sockets is performed to reduce patient healing time. The dental literature presents clear guidelines for patient selection and methods for achieving good outcomes.[2-7] Special attention should be given to evaluate the presence of any horizontal gaps between the implant surface and the labial or lingual plates. Quirynen et al[8] described 5 conditions that might be present when immediate implantation is being carried out, ranging from no gap between the implant and the surrounding bone through various bony defects that may or may not require guided bone regeneration (GBR). It has been postulated that when there is a horizontal gap of 2 mm or more, use of grafting procedure might be recommended.[9-12]

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GBR emphasizes the use of a mechanical barrier to prevent soft tissue from growing into a bony defect before osteogenic cells can seal the gap and develop new bone matrices for osseous regeneration.[13,14] Several clinical studies have addressed the issue of combining GBR with immediate implant placement in fresh extraction sockets using resorbable or nonresorbable membrane alone,[15-17] or in combination with various graft materials.[18-20] In a randomized controlled trial comparing the outcome of implants placed in fresh extraction sockets in maxillary anterior and premolar areas, Chen et al[12] evaluated the necessity of autogenous bone grafting. No statistically significant difference was found regarding vertical defect height and horizontal defect depth between the various augmentation treatments (membrane only, membrane + autogenous bone, autogenous bone, and no graft).

Various grafting materials have been used to fill the gap to ensure the constitution of osseous interface with the implant. Beta tricalcium phosphate (β-TCP) is a biocompatible alloplast[21-23] that has been shown to influence osteoconduction[24-27] simultaneously with osteoblastic activity.[28,29] Histological study in humans[30] found that pure-phase β-TCP had a resorption rate that enabled new bone formation without interfering with the bone matrix. β-TCP has been shown to completely resorb[31,32] and has been successfully used in sinus augmentation procedures.[27,33] However, few studies have evaluated the long-term outcome of using β-TCP as grafting material simultaneously with immediate implantation into fresh extraction sockets.[34]

The purpose of the current study was to assess the long-term results of implants immediately placed into fresh extraction sockets and grafted with β-TCP.

Materials and Methods

A retrospective chart review was conducted of all patients who underwent implant placement therapy between years 1998 and 2000. Treatment planning and rehabilitation were performed by a specialist in prosthodontics, and all the surgical extractions and implant placements were performed by a single surgeon. This study was approved by the Institutional Review Board of Tel-Aviv University, Tel-Aviv, Israel.

Inclusion criteria for study inclusion are summarized in Table 1. Chart data were entered into a secure personal computer using digital software (Microsoft Office Excel 2007, Microsoft Corp, Redmond, WA). Participants were assigned to 1 of 3 study groups based on the treatment method: immediate implant placement into extraction sockets followed by grafting (group A), delayed implant placement into healed sites followed by grafting (group B), and delayed implant placement into healed sites without additional grafting (group C).

Table 1. CRITERIA FOR DENTAL IMPLANT TREATMENT

Inclusion	At least 18 years of age
	Adequate available bone to accommodate an implant
	Systemically and dentally healthy
	Demonstrated ability to maintain oral hygiene
	Willingness and ability to commit to follow-up
	Provide signed informed consent
Exclusion	Lack of skeletal maturity
	Ridges that required significant augmentation for implant site development
	Uncontrolled diseases or conditions that could impede bone healing or soft tissue health
	Mental, emotional, or lifestyle factors that could adversely impact treatment and follow-up

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In all cases, clinical examination included reviews of medical and dental histories, radiographic assessment, and evaluations of oral hygiene. Before treatment, the patient's ability to commit to long-term follow-up was assessed. Study casts were fabricated and mounted on a semi-adjustable articulator using a face bow transfer and vertical registration to determine jaw relationships, available occlusal dimension, proposed implant position, crown-implant ratio, and potential complications. Prosthetic wax-up and surgical template were fabricated to allow guided placement of the implants relative to the planned prosthesis. The treatment plan and alternative options were discussed, and signed informed consent was obtained from each patient before treatment.

Teeth were carefully removed to maintain the extraction walls as much as possible. Implants (Tapered Screw-Vent MTX, Zimmer Dental Inc, Carlsbad, CA) were placed according to the manufacturer's protocol. Criteria for immediate placement of implants included initial implant stability and 4-walled self-contained immediate extraction sites. Horizontal gaps between implant outer surface and the bony plate greater than 1.5 mm were grafted with β-tricalcium phosphate (Cerasorb, Curasan AG, Kleinostheim, Germany) without the use of a membrane, while smaller gaps were not grafted. Criteria for immediate loading were the implant's ability to withstand 20 N-cm of reverse torque immediately after placement and tensionless flap closure. Implants that did not comply with these criteria were subjected to delayed loading after a conventional submerged healing period with no removable provisional restoration.

During annual follow-up, marginal bone changes were calculated from the implant internal hex

Table 2. CRITERIA FOR IMPLANT EVALUATION

Clinical survival	Implant is immobile with manually tested
	No peri-implant radiolucency
	No irresolvable clinical symptoms, such as pain, discomfort, numbness, infection
	No irresolvable mechanical problems
	No fractured components
	Implant is fully functioning according to its intended prosthodontic purpose
Clinical success	Meets implant survival criteria
	Absence of fractured components
	Absence of non-failure-related adverse events
	Peri-implant bone loss does not exceed 1.5 mm
	Meets the patient's clinical and esthetic needs
	Meets the patient's expectations
	Cumulative implant survival is at least 90% after 5 years
	Cumulative implant success is at least 90% after 5 years

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platform to the crestal bone level using standardized radiographs taken at implant placement (baseline). Slight variations were difficult to measure, and there was an inability to control for exact radiologic distortion with this technique, thus bone loss was recorded in incremental ranges of 0 mm to 1 mm, 1 mm to 2 mm, 2 mm to 3 mm, 3 mm to 4 mm, and greater than 4 mm.

Data that were collected at annual prophylaxis appointments included plaque and probing depth measurements using a periodontal probe (Hu-Friedy, Chicago, IL). Criteria evaluating implant clinical survival and clinical success are summarized in Table 2.

STATISTICAL METHODS

Endpoints for each group categorical analysis study were summarized as frequencies and percentages at each level of the variable, and continuous variables were summarized using descriptive statistics (N, mean, median, standard deviation, minimum, and maximum). A Mixed Model Analysis was used. Fixed (parameters) effects were gender, age, health risks, implant length and diameter, time of implant placement, bone graft use, type of restoration, and time of implant loading. The dependent variable was bone loss amount. All analyses were performed using SPSS 15.0 (IBM Corp, Armonk, NY) for the personal computer on the Windows XP operating system.

Table 3. HEALTH RISKS DISTRIBUTION (NUMBER OF PATIENTS)

Time of Placement	Health Risks	β-TCP	No Graft	Total
Immediate		Group A		
Delayed	Smoking	1		1
	Periodontitis	13		13
		Group B	Group C	
	Smoking	1	2	3
	Periodontitis	13	14	27

Group A: Immediate implantation + β-TCP.
Group B: Delayed implantation + β-TCP.
Group C: Delayed implantation, no bone graft.

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Table 4. IMPLANTATION TIME, BONE GRAFT USE, AND IMPLANT LOCATION SITES (NUMBER OF IMPLANTS)

Time of Placement	Location	β-TCP	No graft	Total (254)
Immediate		Group A (79)		
Maxilla	Incisors	23		58
	Canines	9		
	Premolars	21		
	Molars	5		
Mandible	Incisors	7		21
	Canines	2		
	Premolars	7		
	Molars	5		
Delayed		Group B (61)	Group C (114)	
Maxilla	Incisors	11	5	107
	Canines	7	5	
	Premolars	21	28	
	Molars	11	19	
Mandible	Incisors	3	6	68
	Canines	0	6	
	Premolars	5	20	
	Molars	3	25	

Group A: Immediate implantation + β-TCP.
Group B: Delayed implantation + β-TCP.
Group C: Delayed implantation, no bone graft.

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Results

This retrospective study of 58 patients included 33 females (56.89%) and 25 (43.1%) males with mean age of 54.78 (±11.6) years (range: 18 to 78, median 55). Table 3 presents health risks distribution among patients.

Of the 254 implants placed in different locations, 79 were placed immediately with the use of β-TCP as grafting material (group A), and 175 were placed in healed extraction sites (delayed placement). In the delayed placement group, 61 implants placed with the use of β-TCP graft material were assigned to group B, and 114 implants placed without any grafting material were assigned to group C (Table 4). In group A, 74.68% (59/79) of the implants were immediately loaded, while only 24.59% (15/61) of implants in

Table 5. LENGTHS AND DIAMETERS OF DENTAL IMPLANTS

	Diameter (mm)	Length (mm)	Group A (79) No. of Implants	Group B (61) No. of Implants	Group C (114) No. of Implants
Maxilla	3.7	10	0	4	8
		13	32	34	29
		16	13	2	1
	4.7	10	5	3	4
		13	6	3	15
		16	2	3	1
Mandible	3.7	8	0	0	2
		10	14	3	9
		13	1	5	31
	4.7	16	1	1	1
		10	0	0	11
		13	5	2	3

Group A: Immediate implantation + β-TCP.
Group B: Delayed implantation + β-TCP.
Group C: Delayed implantation, no bone graft.

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group B and 32.45% (37/114) of implants in group C were immediately loaded. The distribution of lengths and diameters of dental implants used are shown in Table 5. Mean follow-up was 118.9 months for all implants (range 100 to 126 months).

Fourteen implants were restored with single crowns, 233 were restored with fixed partial dentures (FPDs), and 7 were restored with removable overdentures (Table 6). Bone loss around most implants was not apparent. In one case, 8 mm of bone loss was observed around a single implant (3.7 mm × 13 mm) after 124 months of function. Bone loss of 3 to 4 mm was recorded in 3 patients with history of periodontitis. No implants were lost in this study population. Statistical analysis showed no correlation between implant placement timing (delayed or immediate), the use of bone graft and extent of bone loss. However, there was dependency between bone loss and implants placement in the maxilla (P = .032), which was more pronounced compared with the mandible (0.3 mm ± 0.14 mm) for all treatment protocols. Cumulative implant survival rates were 100% (n = 254) (Table 7).

Table 6. DISTRIBUTION OF RESTORATION TYPE

Restoration Type	Number
Group A	
SC	3
FPD	74
RPD	2
Group B	
SC	6
FPD	55
RPD	0
Group C	
SC	5
FPD	104
RPD	5

Group A: Immediate implantation + β-TCP.
Group B: Delayed implantation + β-TCP.
Group C: Delayed implantation, no bone graft.
Abbreviations: SC, single crowns; FPD, fixed partial dentures; RPD, removable partial denture.

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Discussion

In the present study, horizontal gaps larger than 1.5 mm between the bony wall and immediately placed implants surface were filled with β-TCP without the use of a barrier membrane. This resulted in

Table 7. AMOUNT OF BONE LOSS IN THE DIFFERENT STUDY GROUPS

Bone Loss (mm)	Group A	Group B	Group C
0	57	46	85
1	10	12	16
2	10	1	11
3	1	1	2
4	—	1	—
8	1	—	—

Group A: Immediate implantation + β-TCP.
Group B: Delayed implantation + β-TCP.
Group C: Delayed implantation, no bone graft.

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no bone loss in 72.1% of the implants, which was very similar to the nongrafted cases in which implants were placed in favorable conditions. In fact, comparisons of groups A (immediate implantation + β-TCP), B (delayed implantation with β-TCP), and C (delayed implantation) did not show a statistically significant difference regarding the amount of bone loss after 10 years of follow-up. Moreover, 74.68% (59/79) of implants in group A were adequately stabilized for immediate loading while attaining additional support by augmentation with a pure-phase β-TCP, a material designed to be resorbed simultaneously with the formation of new bone.

Artzi et al[32] investigated the resorption rate and healing site morphology of β-TCP and inorganic bovine bone during 24 months in a canine model and found total resorption of β-TCP particles compared with inorganic bovine bone, with or without the use of protective membrane. Because of the mechanism and rate of TCP resorption, the researchers[32] suggested that there was an advantage to the staged technique (first bone augmentation followed by delayed implantation after healing period) over simultaneous bone augmentation and implant placement.

The most intensive osteogenic activity during healing of extraction sites takes place between 4 and 8 weeks after extraction. This modeling phase involves the activity of osteoblasts and osteoclasts among other healing events.[35]

The described healing process may contribute to the resorption and the osteogenic effect of the osteoconductive material used in this study. These results are in agreement with Chen and Buser[7] regarding the effectiveness of bone fill following immediate implantation, resorption of bone ridges over time, and success of bone augmentation procedures combined with immediate implant placement.

Conclusion

The use of β-TCP (Cerasorb) as a graft material during immediate implant placement allowed no bone loss in 72.1% of the implants, which was very similar to the nongrafted cases for which implants were placed in favorable conditions.

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