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ORIGINAL ARTICLE

Versatility of Basal Cortical Screw Implants with Immediate Functional Loading

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Abstract

Background The purpose of this study is to evaluate the survival rate of the basal cortical screw (BCS) implant system inserted in healed edentulous ridges (*E*) or extraction sockets (ES) with immediate loading functional protocol in varying clinical situations.

Methods A total of 125 BCS implants were placed in 14 patients, immediately loaded and observed for 20.07(± 4.23) months. Ninety-four were placed in *E* sites and 31 were placed in ES sites. They were evaluated for bone loss, soft tissue shrinkage around the prosthesis, improvement in quality of life (QOL), and their survival after 1 year.

Results Total of 121/125(96.8%) implants survived while 4/125(3.2%) failed at the end of follow-up. Average bone loss after 1 year was 0.33 mm (*E*) and − 1.57 mm (ES), average soft tissue shrinkage was 0.50 mm (*E*) and 1.42 mm (ES) and average Patient's Global Impression of Change (PGIC) scale score was 6.36(± 0.63) at 1 year. The complications observed were mobility {3(2.4%)}, pain/discomfort {1(0.8%)} and fracture of abutment at the neck {1(0.8%)}, prosthesis loosening {2(9%)} and requirement of relining {3(13%)}. No periimplantitis was observed.

Conclusion This is the only study to report the marginal bone loss and soft tissue changes around BCS implants and an index-based improvement in QOL of such patients. The BCS implant system with immediate functional loading protocol is a versatile modality to rehabilitate a single tooth, a segment or a full arch with healed ridges as well as extraction sites; it gives high success rate and minimal complications.

Keywords Basal cortical implants · Immediate functional loading · Quality of life improvement · Marginal bone loss · Soft tissue shrinkage

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Introduction

Dental implants have revolutionized the art and science of modern dentistry by providing an aesthetically pleasing appearance via restoring teeth along with oral tissues. They have a better prognosis than other alternatives for fully/partially edentulous arches [1].

For many years, dental implants have been placed and dental arches rehabilitated following the original *Branemark's* protocol of implant submersion for 3–6 months during which osseointegration and uneventful healing takes place. This long treatment period involving wearing a temporary prosthesis, is of great inconvenience [2]. For an implant to be successful, sufficient bone is required (13–15 mm length and 5–7 mm width). Severely atrophic jaws are challenging due to poor quality and quantity of bone. In such cases, alveolar, calvarial or iliac bone grafts, nerve repositioning, and sinus or nasal lift procedures may be used. Despite reported success, these are unpredictable. Moreover, patients may hesitate to undergo additional surgeries [3].

To avoid these surgical measures, one of the solutions for atrophic jaws is "to change the implant design". Basal implants are uniquely and specifically designed to gain anchorage from the basal cortical bone. They have gone through several changes and alterations in the past several decades. According to Gérard M. Scortecci [4], the term *"Basal Implantology"* denotes the lateral or vertical insertion/anchorage of disk-form /root-form implants into the basal bone. The design range includes single/double/triple disk implants, horizontal plate-form implants with osteosynthesis screws or cortical screw implants which can manage the diverse anatomy and bone quality. Immediate loading protocol has been standard in basal implantology for years. Thus, these implants provide fast, minimally invasive, durable, and cost worthy implant treatments.

The purpose of this study is to evaluate the survival rate of the basal cortical screw (BCS) implant system inserted in extraction sockets or healed edentulous ridges with immediate loading protocol in varying clinical situations.

Materials and Methods

This single-center prospective study included 14 subjects treated at the Department of Oral & Maxillofacial Surgery, from 2017 to 2019. A total of 125 one-piece- BCS implants (BECES® or BECES-ex®, and KOC®—Strategic Implant®, Simpladent GmbH, Switzerland, Manufacturer: Dr.Ihde Dental AG) were placed in healed edentulous (*E*)(94 implants) or fresh extraction sites(ES)(31 implants), either in segments or full arches and immediately loaded with a splinted permanent prosthesis in 72 h.

Inclusion criteria were patients with single/multiple missing teeth, atrophic maxilla/mandible, alveolar defects secondary to trauma, diabetics with well-controlled HbA1c levels, cases where conventional implants or bone augmentations had failed and cases which would have required additional procedures like ridge split and bone augmentation.

Patients on bisphosphonate therapy, with uncontrolled diabetes, immunocompromised state, inadequate mouth opening and history of radiation therapy were excluded from study.

A detailed history with clinical examination and radiological evaluation {Orthopantomogram (OPG) and Cone-beam computed tomography (CBCT)} was performed. All implants were assessed for soft tissue shrinkage around the prosthesis and marginal bone loss in the immediate post-operative period (baseline) and then at 6 months and 1 year, respectively. Improvement in the quality of life (QOL) post-treatment with the Patient's Global Impression of Change (PGIC) scale and implant survival rate were assessed after 1 year. On the PGIC scale, patients were asked to mark the appropriate scale out of 7 according to their post-treatment experience.

Implant survival criteria included an absence of mobility, pain, and infection and observed/reported bone loss visible on OPG without pain. Implants that presented with mobility and pain with/without an observable bone loss on radiographs were considered failed implants.

All implants were placed under infiltration of 2% lidocaine with 1:100,000 epinephrine. Implants were placed with the prime objective of cortical anchorage of the load transmitting thread in the second/third (distal) cortical. The pilot drill was used first to initiate the osteotomy- transmucosally in *E* sites and through the extraction sockets in ES sites. Then, the twist drills were used to widen the first cortical (in cases of healed sites) and to penetrate the distal cortical. Experience of a drop like sensation was considered as distal cortical penetration. According to the length at which the distal cortical was reached, the length was selected and implants placed. Ten implants in the maxilla and 8 in the mandible were placed in *strategic positions,* according to the *"Supporting Polygon"* [5] concept. Direct impressions were made with addition silicone and sent to the laboratory with implant analogs in place for construction of the metal framework.

The next day, with the help of reduction jigs, the implant abutments were trimmed to provide an active fit for the metal framework. The prostheses made were either hybrid dentures with acrylic over metal or metal-ceramic bridges. They were cemented with glass ionomer luting cement within 72 h with full functional loading. The prosthetic concept included occlusal contacts on both premolars, the anterior half of the first molar but not distal to that and without anterior contacts (Fig. 1). Sign test was used to analyze the data statistically through IBM SPSS® Statistics ver.26.0 software.

Results

A total of 125 immediately loaded BCS implants (14 patients) were included in this study and observed for an average of 20.07($\pm$ 4.23) months. Among 125 implants, 94(75.20%) were placed in *E* sites and 31(24.80%) were placed in ES sites from which, 86(69.80%) were BECES® implants{59 in *E* sites(68.60%) and 27 in ES sites(31.40%)}, 19 (15.20%) were BECES-Ex® implants{15 in *E* sites(78.95%) and 04 in ES sites(21.05%)} and 20(16.00%) were KOC® implants{in E sites(100%)}(Table 1).

For edentulous sites, the average marginal bone level (the distance between the end of implant abutment and level where the marginal bone contacts the implant) measured on CBCT at baseline was 2.93 mm and after 1 year it

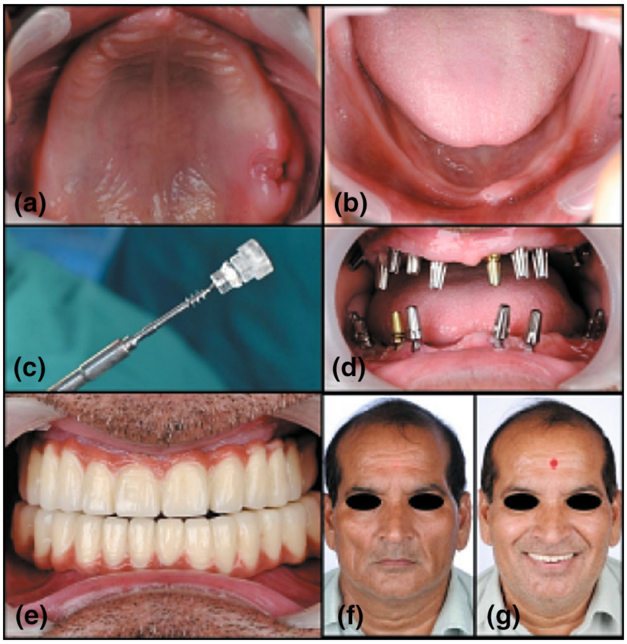

Fig. 1 Case of full mouth rehabilitation with BCS implants in healed ridges. **a** Pre-op maxillary arch. **b** Pre-op mandibular arch. **c** BECES implant. **d** Immediate post implant placement. **e** Metal reinforced ceramic final prosthesis. **f** Pre-op frontal view. **g** Post-op frontal view

was 3.30 mm (Fig. 2). The average bone loss after 1 year was 0.33 mm ($p = 0.0000000038$, statistically significant). For extraction sites, the baseline was 6.29 mm and after 1 year it was 4.72 mm. The average bone loss after 1 year was − 1.57 mm ($p = 0.0000085$, statistically significant-apparently bone gain).

For edentulous sites, the average soft tissue distance from the prosthesis measured with a calibrated probe after prosthesis cementation at baseline was 2.31 mm. At 6 months follow-up, it was 2.81 mm and the average increase in soft tissue distance from the prosthesis margin was 0.5 mm ($p = 0.005$, statistically significant). For extraction sites, the average distance was 1.47 mm at baseline and at 6 months, it was 2.89 mm. The average increase in the distance over 6 months was 1.42 mm ($p = 0.042$, statistically significant). The average PGIC score was 6.36(SD 0.63).

In this study, 121(96.80%) implants met with the pre-defined implant success criteria while 4(3.20%) (3.19% *E*, 3.23% ES) implants did not. The survival rate after the average follow-up of 20.17(± 4.23) months was 96.8%. The complications observed were mobility in 3(2.40%) implants, pain or discomfort in 1(0.80%) and fracture of abutment at the neck during insertion in 1(0.80%) implant. Local soft tissue infection or periimplantitis related complication was not observed. Prosthesis loosening was seen in 2(8.70%) and relining was required in 3(13.04%) prosthesis.

Discussion

Basal implants are used for restoring the vital function and characteristic beauty of the masticatory apparatus in difficult anatomic conditions in a minimally invasive and less time-consuming fashion. Always placed in native living bone, they do not warrant additional procedures like distraction, ridge splitting, grafts, etc. [4].

In our study, 14 patients were treated with a total of 125 basal cortical screw implants using immediate loading protocol in different clinical situations—single tooth, segments, or full arches. Similar studies by Oleg et al. [6], Grag et al. [7], Lazarov [8], Ihde and Ihde [9] also report rehabilitation of different cases ranging from single tooth to full arches with BCS implants.

Among these, 94(75.20%) implants were placed in edentulous sites and 31(24.80%) implants were placed in fresh extraction sockets sites immediately after extraction. Oleg et al. [6] reported 2927(64.1%) implants placed in edentulous sites and 1642(35.9%) implants placed in extraction sockets. Lazarov [8] placed 646(55%) implants in edentulous sites and 524(45%) implants in extraction sockets.

Among all the implants, BECES® type implants were found to be the most versatile; they were used in all different situations and were utilized the maximum (69%) in our study. Oleg et al. [6] and Lazarov [8] also showed BECES® implants being the maximally used basal implant type in their studies 89.6% and 87.1%, respectively.

The penetration areas of implants through the 1st cortical form the supporting (first) polygon (red line). Load transmitting threads penetrating the second cortical of all implants form the second polygon (green lines) (Fig. 3). The canines and the second molars are important *strategic positions* as they determine the shape and extent of the supporting polygon. The rest of the implants are positioned to reinforce the formed polygon.

This concept includes 2 tubero-pterygoid implants on each side and 6 implants in inter-canine region, thus a total of 10 BCS implants in the maxilla. Similarly, a total of 8 BCS implants in the mandible should be placed—4 implants in the inter-foraminal region and 2 on both sides in the distal mandible (Fig. 3) [5]. This number may vary according to the quality of bone and individual case-scenarios.

Replacement of a missing single anterior tooth would necessitate a single implant, while for a missing molar, 2 implants would be required. In segmental cases, 4 missing incisors may be replaced with 2–4 implants. Two missing molars would require 3–4 implants. For completely edentulous quadrants 5–6 implants would be desirable.

Table 1 Observed results of marginal bone loss, soft tissue shrinkage and PGIC scale: E—Edentulous sites, ES—Extraction sites, F—Failed implants

Observed results of marginal bone loss, soft tissue shrinkage & PGIC scale

Sub No.	Sample No.	Implant site	Implant type	Average bone loss (at 1 year)	Soft tissue shrinkage (at 6 months)	PGIC scale score (at 1 year)	Sub No.	Sample No.	Implant site	Implant type	Average bone loss (at 1 year)	Soft tissue shrinkage (at 6 months)	PGIC scale score (at 1 year)
1	1	E	BECES	0.36	0.5	7	3	37	E	BECES ex	− 0.60	0.75	6
	2	E	BECES	1.36				38	E	BECES ex	0.20		
	3	E	BECES	0.37				39	E	KOC	1.59		
	4	E	BECES ex	0.92				40	E	BECES	0.07		
	5	E	BECES	0.54				41	E	BECES	1.10		
	6	E	BECES	0.05				42	E	BECES	− 0.41		
	7	E	BECES ex	− 0.04				43	E	KOC	− 0.55		
	8	E	BECES ex	0.30				44	E	BECES	0.66		
	9	E	BECES	1.37				45	E	BECES ex	− 0.94		
	10	E	BECES	1.33				46	E	BECES	F		
	11	E	BECES ex	0.21				47	E	BECES	− 0.67		
	12	E	BECES ex	0.16				48	E	BECES	− 0.33		
	13	E	BECES	0.29				49	E	BECES	0.04		
	14	E	BECES	− 0.05				50	E	BECES	0.13		
	15	E	BECES	0.01				51	E	BECES	− 1.03		
	16	E	BECES	− 0.50				52	E	BECES	0.46		
	17	E	BECES	− 0.01				53	E	BECES	1.73		
	18	E	BECES	0.53				54	E	BECES	0.42		
2	19	E	BECES	0.07	0.5	5	4	55	E	BECES	0.55	0	7
	20	E	BECES ex	0.14				56	E	BECES	0.31		
	21	E	BECES ex	0.02			5	57	ES	BECES	− 0.55	0	6
	22	E	BECES	0.15			6	58	ES	BECES	− 3.98	2.5	7
	23	E	BECES	0.13				59	ES	BECES	− 3.79		
	24	E	BECES	0.22				60	ES	BECES	1.55		
	25	E		0.35				61	ES	BECES	1.39		

Table 1 continued

Observed results of marginal bone loss, soft tissue shrinkage & PGIC scale

Sub No.	Sample No.	Implant site	Implant type	Average bone loss (at 1 year)	Soft tissue shrinkage (at 6 months)	PGIC scale score (at 1 year)	Sub No.	Sample No.	Implant site	Implant type	Average bone loss (at 1 year)	Soft tissue shrinkage (at 6 months)	PGIC scale score (at 1 year)
			BECES ex										
	26	E	BECES	0.44				62	ES	BECES	− 1.10		
	27	E	BECES	0.22				63	ES	BECES	− 2.95		
	28	E	BECES ex	F				64	ES	BECES	− 3.76		
	29	E	BECES	0.67				65	ES	BECES	− 4.35		
	30	E	BECES	0.24				66	ES	BECES	F		
	31	E	BECES	0.55				67	ES	BECES	− 3.63		
	32	E	BECES	0.89				68	ES	BECES	− 2.64		
	33	E	BECES	1.20				69	ES	BECES	− 2.57		
	34	E	BECES	0.62				70	ES	BECES	− 1.38		
	35	E	BECES	0.97				71	ES	BECES	− 1.05		
	36	E	BECES	F				72	ES	BECES	− 1.19		
6	73	ES	BECES	− 1.37	2.5	7	10	111	ES	BECES ex	− 0.25	1	7
	74	ES	BECES	− 2.68				112	ES	BECES	− 0.49		
7	75	E	BECES	0.07	0.75	7	11	113	F	KOC	0.24	0	6
	76	E	BECES	0.21				114	F	KOC	0.04		
	77	E	BECES	0.58				115	F	BECES ex	0.23		
	78	E	BECES	0.39			12	116	ES	BECES	− 0.55	3	6
	79	E	BECES	0.31				117	ES	BECES	− 0.65		
	80	E	BECES	0.33				118	ES	BECES	0.38		
	81	E	BECES ex	0.12				119	ES	BECES ex	− 0.19		
	82	E	BECES	0.30			13	120	E	BECES	0.26	1	6
	83	E	BECES	0.64				121	E	KOC	0.50		
	84	E	BECES	0.32				122	E	KOC	0.20		
	85	E	BECES	0.81				123	E	BECES	0.31		
	86	E	BECES	0.19				124	E	BECES	0.26		
	87	E	KOC	0.11			14	125	ES	BECES ex	− 0.49	0	6
	88	E	KOC	0.42									
	89	E	KOC	0.32									

Table 1 continued

Observed results of marginal bone loss, soft tissue shrinkage & PGIC scale

Sub No.	Sample No.	Implant site	Implant type	Average bone loss (at 1 year)	Soft tissue shrinkage (at 6 months)	PGIC scale score (at 1 year)	Sub No.	Sample No.	Implant site	Implant type	Average bone loss (at 1 year)	Soft tissue shrinkage (at 6 months)	PGIC scale score (at 1 year)
	90	E	KOC	0.64									
	91	E	BECES	0.70									
	92	E	BECES	0.46									
8	93	E	KOC	2.04	0.5	6							
	94	E	KOC	1.76									
	95	E	KOC	− 0.55									
	96	E	KOC	0.12									
	97	E	KOC	− 0.49									
9	98	ES	BECES	− 2.28	2	7							
	99	ES	BECES	− 1.15									
	100	ES	BECES	− 1.20									
10	101	E	KOC	− 0.21	1	7							
	102	E	KOC	− 0.27									
	103	E	BECES	0.17									
	104	E	BECES ex	0.26									
	105	E	KOC	0.23									
	106	E	KOC	0.77									
	107	E	KOC	0.57									
	108	ES	BECES	− 4.42									
	109	ES	BECES ex	− 0.86									
	110	ES	BECES	− 1.13									

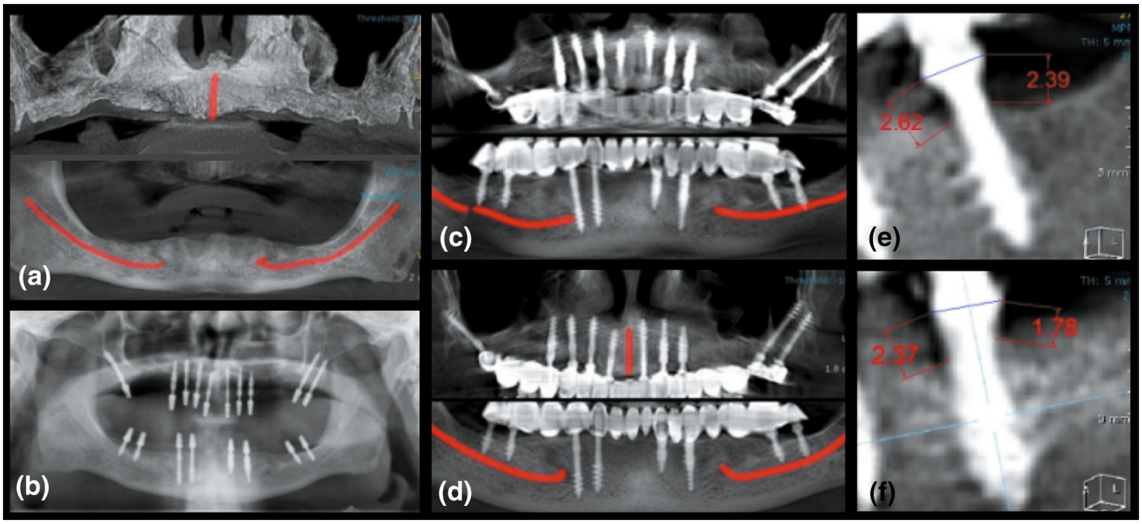

Fig. 2 Radiographs. **a** Pre-op CBCT. **b** Post implant placement OPG. **c** Immediate post implant CBCT. **d** CBCT at 1-year post-op. **e** Marginal bone levels immediate post implant. **f** Marginal bone levels at 1-year post-op

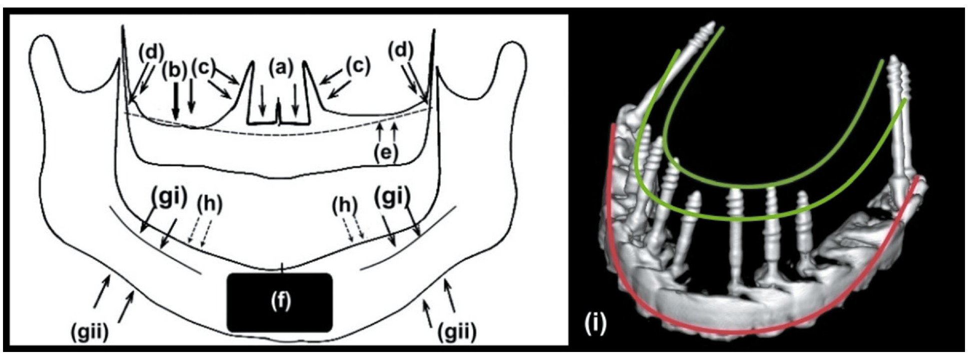

Fig. 3 Strategic implant sites and Supporting polygon: **a** floor of the nose, **b** floor of the sinus, **c** nasomaxillary buttress, **d** pterygoid plate of the sphenoid bone, **e** bone areas palatal to the maxillary sinus, **f** Inter-foraminal anchorage, **g** Distal mandible, anchorage with second cortical either, (1) lingual engagement or (2) buccal engagement (BECES/BECES-ex), **h** Distal mandible, without cortical engagement (compression screws), **i** Supporting polygon—red line –first polygon, green lines- second polygon (Adopted form Ihde, Stefan, et al. "New Systematic Terminology of Cortical Bone Areas for Osseo-Fixated Implants in Strategic Oral Implantology." J J Anatomy, vol. 2016, no. 2, 2016, p.7 and modified)

After the distal cortical engagement, the implants were bent from their neck up to 10–45° (max 45° BECES®, 25° BECES-ex®, 15° KOC®) to provide a more favorable prosthetic base. Bending the implants could lead to internal stresses in the shaft, executing high forces on the bone. With all parameters identical, bendable implants exhibit a more uniform stress distribution along the vertical implant region than identically shaped machine-angulated implants.

Goldmann et al. [10] reported that bendable implants possibly oppose masticatory loads better than pre-angulated and even non-bent implants, which have a thin vertical implant area. Oleg et al. [6] found that bent implants had better survival rates (98.3%) than unbent implants (94.2%).

Rigid metal framed hybrid denture with acrylic resin or ceramic veneered prostheses were fixed within 72 h of implant placement. The advantage of using the resin teeth is that they absorb most of the forces in initial healing. This may be specially beneficial in atrophic bone [3]. The implants must be rigidly splinted with metal reinforced prosthesis and delivered within 72 h, thereby beginning immediate functional loading. The reason for this time limit is that afterward, the "Resorption Phase" and osteoclastic activity start [11], resulting in a significant reduction in the high initial stability of the implants.

This is similar to the concept used in the field of traumatology to splint the fractures segments, which provide early load transmission over a stable base. After the surgery, early return to routine functional activities is encouraged.

There is a limited role for variously treated implant surfaces for immediate loading protocol [5], as in 72 h, the bone neither heals nor integrates with the implant devices. The basal implants and internal fixation devices of traumatology are considered "osseofixated" in stable cortical bone with almost no metabolism [10]. Secondary osseointegration would occur later into the endosseous parts of the implants contacting cancellous bone.

Albrektsson's success criteria [12] for conventional implants states that the average marginal bone loss around an implant should not be more than 1.5 mm in the first 12 months post functional loading. Buser et al. [13] reported marginal bone loss of 0.4–1.2 mm after a year of flapless implant placement. In our cases, the average bone loss for edentulous sites at 1 year was 0.33 mm ($p < 0.05$), which though was statistically significant, was less than the range of accepted bone loss for the conventional implants after the first year.

For extraction sites, the bone loss after one year was − 1.57 mm ($p < 0.05$), which indicates that eventually all the extraction sites healed with the formation of new bone around implant shafts. These findings were similar to the study conducted by Oleg et al. [6] in which vertically along the implant, the bone had remodeled post-extraction both anteriorly and posteriorly.

Although there are studies [2, 7, 9, 14] which report immediate placement of BCS implants, but none of them assessed the soft tissue changes around prosthesis. Over 6 months, in our study, edentulous sites showed average soft tissue shrinkage of 0.50 mm ($p < 0.05$). Similarly, extraction sites showed an average soft tissue shrinkage of 1.42 mm ($p < 0.05$). It was more than that of the edentulous sites. This advocates that with the healing of the sockets and concomitant remodeling of alveolar bone, the soft tissue shrinkage takes place too; which would not be much evident in cases of edentulous sites.

In cases with higher soft tissue shrinkage, a second prosthesis may become necessary after 6–8 months to close the gaps between the prosthesis and gingival margins. Rebasing with cold cure acrylic intraorally should be discouraged as the polishing of the added surface cannot be done inside the oral cavity. Such an unpolished surface of added acrylic may cause chronic irritation of mucosa as it may lead to soft and hard tissue infection around implants. The prosthesis over healed mucosa in the edentulous sites does not require a second prosthesis. Also, they adapt their phonetics faster and function well [14].

In this study, PGIC scale was used to measure the improvement in the QOL. The WHO defines QOL as "*an individual's perception of their position in life in the context of their culture and value systems and relation to their goals, expectations, standards, and concerns*"[15]. Dental implants can improve the daily performance of a patient and improve his confidence and social life drastically. Our average PGIC score was 6.36(± 0.63).

Sargolzaie et al. [16] conducted an analytical cross-sectional study to compare QOL of patients requiring implants and found that implants had a promising impact on a patient's QOL.

In our average observation period of 20.07(± 4.23) months, 3(2.40%) implants showed vertical mobility and 1(0.80%) implant caused pain and discomfort. They did not measure up to the predetermined success criteria and were considered failed implants (3.20%). They were removed and replaced by other implants but the latter were not considered in this study. The remaining 121 implants were successful.

The overall success rate of this study was 96.80%; with that of implants in edentulous sites being 96.81% and in extraction sockets being 96.77%. Thus, the survival of BCS implants was similar, irrespective of whether they were placed in healed ridges or extraction sockets.

Lazarov [8], demonstrated mobility in 0.3%, pain in 0.3%, discomfort in 0.2% and therefore a high implant survival rate of 95.7%. Over 57 months, he too reported similar survival rate of implants, whether they were placed in healed ridges or extraction sockets. Oleg et al. [6] after 18.93(± 8.41) months reported mobility in 0.4%, local soft tissue infection in 0.1%, pain in 0.2%, discomfort in 0.5% of implants placed with a survival rate was 95.7%.

In our study, 1(0.80%) implant abutment in the distal mandibular region fractured at the neck during insertion. The probable reason was the application of high insertion torque over a KOC® implant with a thin neck diameter. However, the remaining neck portion was used as an abutment and included in the prosthesis by casting the prosthesis over it. The implant fracture could have been avoided by removing the implant, making the osteotomy wider and then reinserting the implant. Local soft tissue infection or periimplantitis related complications were not found during this study. Relining was required in 3(13.04%) prostheses due to considerable soft tissue shrinkage after 6 months. They were removed intentionally with routine bridge removal methods and after relining, were recemented.

The results of our study may be limited when it comes to assessing whether smoking, systemic co-morbidities and different implant types and their bending influenced the success of BCS implant system. Moreover, a longer follow-up with a greater number of implants would be required to get more comprehensive results.

Conclusion

In the present literature, this is the only study that reports the measured marginal bone loss and soft tissue changes around BCS implants, as also an index-based improvement in the quality of life of such patients. Basal cortical implant system with immediate functional loading protocol is a versatile modality to rehabilitate a single tooth, a segment, or a full arch with healed ridges as well as extraction sites. It provides immediate function, improves one's quality of life, gives high success rate with minimal complications.

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Author's contribution Dr. Hrushikesh Gosai did all preoperative preparations, history taking and contributed in planning alongwith post-operative care, proper follow-up, maintenance of the records as well as wrote this paper, Dr. Sonal Anchlia performed surgery and reviewed the paper entirely, Dr. Kiran Patel planned & performed surgery. Dr. Utsav Bhatt planned and performed surgery, reviewed paper critically in discussion and conclusion aspects particularly, Dr. Philip Chaudhari and Dr. Nisha Garg positively contributed to write the paper.

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Declarations

Conflict of interest None of the authors has any conflict of interest.

Consent for publication Each patient was explained about the treatment plan and written informed consent was obtained.

Ethical approval The study protocol was approved by The Institutional Ethical Committee.

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