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Retrospective Study of Biohorizons® Implants Placed by Postgraduate Students at the University of Barcelona

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Abstract: The study aimed to evaluate the survival and failure rate, in the short- and medium-term, in addition to its relationship with risk factors, in implants placed by postgraduate students of the Master of Medicine, Surgery, and Oral Implantology course from the University of Barcelona. The study was designed including 192 patients with 422 implants placed between 2015 and 2018. Variables of implant failure were evaluated and related. Failure was split into early failure and late failure. Qualitative data were compared using the chi-squared test, taking $p \leq 0.05$ as a significant value. The comparison of quantitative variables was carried out using the Student's t-test for independent samples. The survival rate in a period of 6 months to 3 years was 97.87%. The mean age of the patients was (54.5 ± 13), and the largest number of implants were placed in the 51–60 age range. The failure rate was 2.13% (N = 9), 6 failed early and 3 failed after definitive prosthetic loading, with a p value < 0.0001. When comparing the failures according to their location in the anterior/posterior sector of the arch, the anterior sector showed statistically significant results ($p = 0.027$). Failed implants had a statistically significant relationship when they were placed in the anterior sector and were performed in the early stage.

Keywords: dentistry; dental implants; survival rate; implant failure; implant success; oral surgery

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1. Introduction

As a highly effective and predictable treatment over time, osseointegrated implants are currently the prosthetic rehabilitation procedure of choice for returning functionality and aesthetics to partially and fully edentulous patients [1]. Longitudinal studies have provided evidence for an implant survival rate of 89–96% over a period of 10 years [2–4].

Although implantology treatment in odontology is predictable, complications can still occur, which directly influence success and failure rates. Some of the most prevalent complications include peri-implant mucositis (19–65%), peri-implantitis (1–47%) [3,5,6], the aesthetic and mechanical failures of the prosthetic rehabilitation [7], and the complete loss of the implant osseointegration, pre- and post-functional load [8,9].

The success of dental implants is related to both the surgical technique and a series of factors that can contribute to their failure over the short-term. Insufficient crestal bone height or width can require regenerative surgeries that sometimes occur simultaneously with implant placement, and can lead to complications, such as soft tissue dehiscence, infections, or insufficient final bone quality [10,11]. On the one hand, it has been shown that among patients receiving sinus lifts, guided bone regenerations, splits, or bone grafts

among other bone regeneration techniques, the success rate of fitted implants is similar to implants placed into native bone and close to 96.4% [12–14]. In other matters, a range of investigations have shown that the patient's systemic condition, including diabetes [15], hypertension [16], osteoporosis [17], allergies [18,19], smoking [20], periodontitis [21], and different habits (oral hygiene [22] or parafunctions [23] among others), is a risk factor for treatment with implants [2,4,24,25], particularly when not controlled.

Most of the data referring to failure and survival percentages in the literature have been provided by experienced surgeons, expert teams with links to commercial brands, or private professionals [3,26]. However, there are limited data on success, survival, and failure percentages of dental implants placed by postgraduate students. Prior studies have shown that operators skills influence implant osseointegration, with success rates of 84.0% during the first 50 implants, with the rate increasing to 94.4% among later implants [27]. Scientific investigations with undergraduate students have shown a success and survival rate with over 5 years' follow up of 88.0% and 97.2%, respectively [28], while the percentages for postgraduate students are 94.62% and 96.15%, respectively, at one year of follow-up [29].

Based on the presented data, this investigation aims to evaluate the survival and failure rate in the short- and long term of Biohorizons® implants placed by postgraduate students of the Master of Medicine, Surgery, and Oral Implantology course of the University of Barcelona. In addition, it aims to evaluate the relationship between failure and the systemic status of patients.

2. Materials and Methods

A retrospective descriptive study was conducted of the surgical procedures and their follow-up among patients fitted with Biohorizons® (Camlog Ibérica, Barcelona, Spain) implants with a conical morphology, straight neck, and internal hex connection by third-year master's students, taught by the lecturers of the Master of Medicine, Surgery, and Oral Implantology course at the University of Barcelona between July 2015 and July 2018. All the prosthodontic rehabilitations were performed during the Master of Occlusion and Oral Rehabilitation course at the University of Barcelona.

Each patient's clinical and radiographic data were collected from the medical records and the institution's files. Once considered suitable, the medical histories were initially reviewed by AGD and JLL, with any discrepancies resolved by consulting with RAM. The medical histories were initially reviewed and were considered suitable if they contained clinical data for surgical and prosthetics during the follow-up period.

The following inclusion criteria were used: (i)—patient aged between 18 and 85 years; (ii)—all patients who were treated with Biohorizons® implants, with a conical morphology, straight neck, and internal hex connection in their different diameters and heights; (iii)—availability of each patient's full medical history; (iv)—healthy patients or those with one or more of the following risk factors: autoimmune disease, osteoporosis, treatment with bisphosphonates, diabetes, cardiovascular disease, periodontal disease and/or allergy to drugs, smoking; (v)—patients who received implants in native bone or combined with bone regeneration; (vi)—availability of pre-operative, operative, and post-operative data, both immediately and after at least 6 months, along with check-ups at 12, 24, and 36 months where available, based on the prosthesis placement date after the implants were inserted; (vii)—availability of pre-, post-operative, and follow-up X-rays if contained in the medical history; (viii)—rehabilitated patients with fixed or removable prostheses.

Patients were excluded when: there was a lack of surgical and prosthetic data in the medical history; when the medical history was not in electronic format; if treated from 2018 onwards; surgeries were not performed by master's students; patients with uncontrolled systemic disease; patients that did not provide informed consent to use their data on initiating treatment.

The variables were divided into 2 groups, the first group relating to the patient's medical history and the second relating to surgery, prosthetic rehabilitation, and implant maintenance (Table 1).

Table 1. Variables' descriptions. M: Male; F: Female; Type: Refers to the type of autoimmune disease: Lichen, Psoriasis, etc.

Variables—Medical History		Type of Variable
Age	-	Quantitative discrete
Gender	(M/F)	Qualitative dichotomous
Bruxism	(Yes/No)	Qualitative dichotomous
Autoimmune disease	(Yes/No)//Type	Nominal qualitative dichotomous
Osteoporosis	(Yes/No)	Qualitative dichotomous
Bisphosphonates	(Yes/No)	Qualitative dichotomous
Diabetes	(Yes/No)//Type	Nominal qualitative dichotomous
Cardiovascular disease	(Yes/No)//Type	Nominal qualitative dichotomous
Smoking habit	(Yes/No)//(<10/>10 day)	Ordinal qualitative dichotomous
Periodontal disease	(Yes/No)	Qualitative dichotomous
Allergy to drugs	(Yes/No)//Type	Nominal qualitative dichotomous
Implant-associated variables		Type of variable
Anatomical location	Anterior maxilla Posterior maxilla Anterior mandible Posterior mandible	Nominal qualitative polychotomous
Implant diameter		Quantitative discrete
Height		Quantitative discrete
Surgical variables		Type of variable
Post-extraction	(Yes/No)	Qualitative dichotomous
Delayed	(Yes/No)	Qualitative dichotomous
GBR	(Yes/No)	Qualitative dichotomous
Sinus augmentation	(Yes/No) Atraumatic//Delayed// Simultaneous	Nominal qualitative polychotomous
Prosthetic load variables		Type of variable
Immediate load	(Yes/No)	Qualitative dichotomous
Delayed load	(Yes/No)	Qualitative dichotomous
Late load	(Yes/No)	Qualitative dichotomous
Prosthesis post-load variables		Type of variable
Type of prosthesis	(Fixed/Removable)	Qualitative dichotomous
Functional implant	(Yes/No)	Qualitative dichotomous
Explantation	(Yes/No)//Type	Nominal qualitative dichotomous

- Variables based on the patient's medical history. Data and predisposing factors relating to the success of the implants described in the literature were studied, such as: (i)—age; (ii)—gender; (iii)—parafunctional habits; (iv)—the patient's systemic condition: autoimmune disease, osteoporosis, treatment with bisphosphonates, diabetes,

cardiovascular disease, periodontal disease, and/or allergy to drugs; (v)—smoking (<10 cigarettes a day/>10 cigarettes a day).

- Variables relating to the surgery and implant data, the prosthetic load, and type of rehabilitation: (i)—Anatomical location. It was divided into four regions (anterior maxilla 1.4–2.4, posterior maxilla, anterior mandible 3.4–4.4, posterior mandible). (ii)—Implant characteristics: the implant diameter (mm) and height (mm) were evaluated. (iii)—Surgery characteristics: the implants were placed post-extraction, delayed, with prior or simultaneous regeneration surgeries (vertical or horizontal bone augmentation), and if sinus lift was necessary (lateral or atraumatic window). (iv)—Prosthetic load: it was described whether the load was immediate (24 h post), a delayed load (2–3 months), or a late load (6 months); (v)—Type of prosthesis: fixed or removable. (vi)—The implant survival was evaluated after verifying in the radiographic data and the clinical history if these were functionally stable at 6, 12, 24, and 36 months after loading. (vii)—Implant failure was considered when it was indicated to remove the implant due to some irreversible complication such as mobility and persistent pain; this, in turn, was divided into early failure (before prosthetic load) and late failure (after final prosthetic load).
- Statistical analysis: Descriptive statistical parameters were used to evaluate the variables, which included standard deviation and percentage distribution. The chi-squared test was used to compare the qualitative data, with $p = 0.05$ considered as a significant value, expressed in frequency distribution tables. The Student's *t*-test for independent samples was used to compare quantitative variables. An Excel table was used to process the data and version 26.0 of the IBM SPSS Statistics, IBM Corporation, Armonk, NY. program was used for the statistical analysis.

3. Results

After obtaining a list of 204 cases treated with Biohorizons® implants, the study focused on 192 patients due to the lack of clinical data for the surgery (seven patients) and an incorrectly filed history number (five patients). The results are presented below according to:

3.1. Gender and Age

As such, the analyzed data corresponded to 192 patients with 422 implants placed in total. With respect to gender, 98 cases were male (51.04%) and 94 cases were female (48.96%). Of the total number of implants (N = 422), 249 were placed in male and 173 in female. The average age of the patients was 54.5 ± 13 years old (range: 17–82 years old) at the time of surgery. Figure 1 shows the distribution of patients and the number of implants divided by age decades and gender. The higher percentages of patients treated with dental implants were in the 41-to-50-year-old (25.52%) and 51-to-60-year-old (25.00%) ranges; while most implants were placed in the 51–60- (26.03%) and 61–70-years-old (25.83%) ranges.

3.2. Medical History

The results regarding the clinical records of the patients are shown in Table 2. The only parafunctional habit described in the medical histories was bruxism, among 14.14% of cases (N = 27), with only one patient presenting the failure of one implant, $p = 0.762$, so the difference was not statistically significant. Of the 28.1% of patient cases (N = 68) with a history of periodontal disease, 3.7% presented failure on treatment with implants (N = 3), $p = 0.920$, so the difference was not statistically significant. When it comes to drug allergies, 11.02% of patients presented allergies to some type of drug, with allergies to penicillins the most frequent among 5.07% of cases (N = 11). Descriptions of the allergies reported in the patients are shown in Table 2. There was only one failure among a patient allergic to different drugs, with $p < 0.0001$. Other variables such as drug abuse were not found in this study. Patients with a known smoking habit were divided into those that smoked fewer than 10 cigarettes a day, 9.95% (N = 19), and those that smoked more than 10 cigarettes

a day, 15.18% (N = 29). Of the nine failures, 5.9% presented in the first group and 3.8% (N = 1) in the second group, with no significant differences and $p = 0.953$.

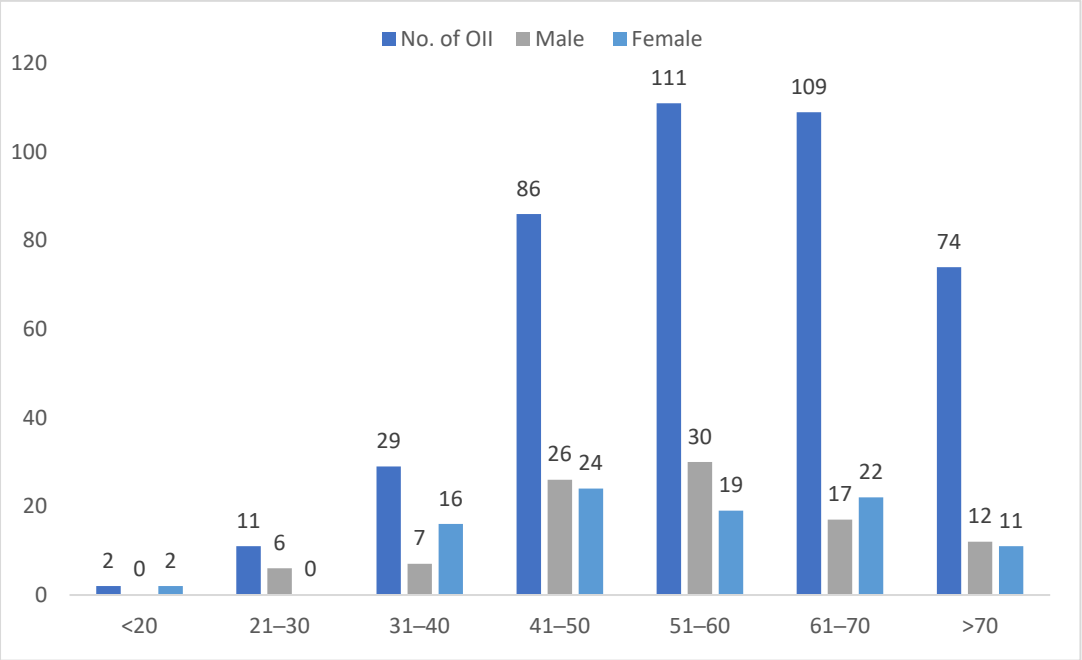

Figure 1. Implant distribution by gender and age range.

3.3. The Distribution of Implants by Location

An average of 2.2 Biohorizons® brand implants were fitted per patient (range: 1–12). A total of 225 implants were placed in the superior maxilla (53.32%), 116 in the anterior sector up to the first premolar and 109 in the posterior sector, while in the mandible, there were 197 implants (46.68%), 60 in the anterior sector up to the first premolar and 137 in the posterior sector. The implants did not present statistically significant values in terms of the position regarding the arches, six failed in the maxilla (2.7% of the total of implants placed in the maxilla) and three in the mandible (1.5% of the total implants placed in the mandible), with $p = 0.417$. During the analysis of failure relating to the position of the implants between the anterior N = 7 (4.0%) and posterior N = 2 (0.8%) sectors, the results showed statistically significant differences with $p = 0.027$. The distribution of implants by location, diameter, and length is shown in Table 3, with the region of the first molar replaced most by implants, both superior and inferior. The most common length was 12 mm, N = 217 (51.42%), and the most used diameter was 3.8 mm, N = 237 (55.92%).

3.4. Type of Surgery and Rehabilitation

Surgery and prosthetic rehabilitation are described in (Table 4). A total of 54 implants were placed post-extraction, 22 of which had an immediate load. A total of 50 patients received a regeneration procedure in combination with placing implants. A total of 64% of cases were regenerated with a xenograft and collagen membrane (Bio-oss®-Bio-guide®, Inibsa Dental S.L.U, Lliçà de Vall-Barcelona, Spain), without specifying the type of regeneration. A total of 20 sinus lifts were performed; implant placement was delayed for 2 of them, with the other 18 placed simultaneously (14 with a lateral window and 4 with a transalveolar technique). A total of 8.5% (N = 5) of the total percentage of patients treated with dental implants and bone regeneration failed, which was not a statistically significant value, with $p = 0.098$.

Table 2. Demographic data and medical histories of the sample. N: number; OII: number of implants. HIV: human immunodeficiency virus; NSAIDs: nonsteroidal anti-inflammatories.

Variables		N Patients/N of OII	Percentage
Gender	-		
-	Male	98/249	51.04%/59%
-	Female	94/173	48.96%/41%
Age ($\overline{X} \pm$ SD)	-	54.5 ± 13	-
Autoimmune diseases		-	-
-	Fibromyalgia	4	2.09
-	Lichen Planus	1	0.52
	Psoriasis	2	1.04
	HIV	1	0.52
Osteoporosis		1	0.52
Bisphosphonates		4	2.09
Diabetes			
	Type 1	1	0.52
	Type 2	12	6.28
	Gestational	1	0.52
Cardiovascular diseases			
	Hypertension	47	24.6
	Arrhythmias	9	4.71
	Chest angina	5	2.61
	Heart failure	2	1.04
	Ischemic heart disease	1	0.52
	Arterial occlusive disease	1	0.52
	Hypotension	1	0.52
	Aneurysm	1	0.52
	Cerebrovascular accident	1	0.52
	Stroke	1	0.52
	Myocardial infarction	2	1.04
	Valvulopathy	1	0.52
Parafunctional habits			
	Bruxism	27	14.13
Periodontal disease		68	35.6
Smoking habit			
	<10 cigarettes a day	19	9.94
	>10 cigarettes a day	29	15.18

Table 2. *Cont.*

Variables	N Patients/N of OII	Percentage
Allergy to drugs		
Penicillins	11	5.75
Sulfamides	2	1.04
Erythromycin	1	0.52
NSAIDs	4	2.09
Acetylsalicylic acid	2	1.04
Metamizole	2	1.04
Ethylenediamine	1	0.52
Benzocaine	1	0.52
Primperan	1	0.52

When it comes to results based on the time of loading, 93 implants (22.04%) were rehabilitated immediately (24 h) with provisional prostheses. Only 11 implants (2,60%) were rehabilitated with an early load within a period of 2 to 3 months, and 269 (63.74%) implants had delayed loading ($\geq$6 months), which was the longest time used to subject a load to the implant. There was no prosthetic load record for 18 patients, totaling 40 implants (9.48%). A fixed prosthesis was used most in 338 implants (80.09%), while the removable prosthesis was only used in 35 mandible implants (8.29%).

3.5. Type of Failure

Nine implants failed in nine patients (2.13%), 66.6% (N = 6) in male and 33.3% (N = 3) in female, with no statistically significant differences, $p = 0.337$. They were divided into early failures pre-prosthetic load (4 implants) with an average follow-up of 13 weeks (range: 4–20 weeks), 2 implants with early failures with an immediate load (4th and 8th week), and 3 implant failures after applying the definitive prosthetic load, with a mean follow-up of 16 weeks (range: 2–32 weeks). The results were statistically significant with $p < 0.0001$ for early failure compared to late failure. Early/late failure was also evaluated regarding implant position, also presenting statistically significant results for implants placed in the anterior region, with $p = 0.014$. Table 5; Table 6 show correlations between variables and failure. Table 7 summarizes the possible causes for explanation and the clinical characteristics.

Table 3. Implant distribution by location, diameter, and length. No. of OII: number of osteointegrated implants; Q: quadrant; F: frequency; D: diameter; L: length; OII: osseointegrated implant; NA: not applicable (the diameter and length of the implants were not classified by location).

Location	No. of OII	%	1stQ N° of OII/%			2ndQ N° of OII/%			3rdQ N° of OII/%			4thQ N° of OII/%			D	No. of OII	%	L	No. of OII	%
Maxilla	225	0.53	1.1	9	7.76	2.1	11	10.1	3.1	3	3.0	4.1	3	3.09	3.0 mm	19	4.5	6 mm	3	0.71
Anterior	116	0.52	1.2	14	12.07	2.2	10	9.17	3.2	11	11.0	4.2	14	14.43	3.4 mm	17	4.03	7.5 mm	3	0.71
Posterior	109	0.48	1.3	15	12.93	2.3	10	9.17	3.3	5	5.0	4.3	5	5.15	3.8 mm	237	56.16	9 mm	34	8.06
Mandible	197	0.47	1.4	21	18.01	2.4	26	23.9	3.4	10	10.0	4.4	9	9.28	4.6 mm	133	31.52	10.5 mm	152	36.02
Anterior	60	0.30	1.5	16	13.79	2.5	20	18.4	3.5	15	15.0	4.5	10	10.31	5.8 mm	16	3.79	12 mm	217	51.42
Posterior	137	0.70	1.6	34	29.31	2.6	26	23.9	3.6	46	46.0	4.6	46	42.27	NA	NA	NA	15 mm	12	2.84
			1.7	7	6.03	2.7	6	5.5	3.7	10	10.0	4.7	10	10.31	NA	NA	NA	18 mm	1	0.24
Total	422	100		116	100		109	100		100	100		97	100	Total	422	100		422	100

Table 4. Characteristics of the surgery and prosthetic rehabilitation. GBR: guided bone regeneration.

Surgery Characteristics				
-	No. Patients/Total	%	No. Implants/Total	%
Surgical periods	-	-	-	-
Post-extraction implants	30/192	15.63%	53/422	12.56%
Delayed implants	162/192	84.38%	369/422	87.44%
Type of regeneration	-	-	-	-
GBR	32/192	16.67%	-	-
Bone expansion	8/192	4.17%	-	-
Chin graft	1/192	0.52%	-	-
Autologous graft	1/192	0.52%	-	-
Cytoplast	1/192	0.52%	-	-
Unspecified	6/192	3.13%	-	-
Sinus Lift	-	-	-	-
Transcrestal	4/192	2.08%	-	-
Simultaneous with lateral window	14/192	7.29%	-	-
Delayed with lateral window	2/192	1.04%	-	-
Characteristics of the prosthetic rehabilitation				
Load type	-	-	-	-
24 h immediate load	17/192	8.85%	93/422	22.04%
Delayed load (2–3 months)	9/192	4.69%	11/422	2.60%
Late load (6 months)	147/192	76.56%	269/422	63.74%
Explantation	9/192	4.69%	9/422	2.13%
No load recorded	18/192	9.38%	40/422	9.48%
Type of prosthesis	-	-	-	-
Fixed	162/192	84.38%	338/422	80.09%
Removable	10/192	5.21%	35/422	8.29%

Table 5. Association between medical characteristics and implant failure.

Demographics and Medical Variables	Failure n = (%)	No Failure n = (%)	*p*-Value
Gender Male	6 (6.1%)	92 (93.9%)	0.337
Female	3 (3.2%)	93 (96.8%)	
Age	9 (57.44 ± 14.8)	183 (53.58 ± 13.4)	0.403
Parafunctional habits	1 (3.6%)	27 (96.4%)	0.762
Autoimmune disease	0 (0%)	8 (100%)	0.982
Osteoporosis	0 (0%)	1 (100%)	0.699
Bisphosphonates	0 (0%)	4 (100%)	0.904
Diabetes Type 2	1 (8.3%)	11 (91.7%)	0.915

Table 5. *Cont.*

Demographics and Medical Variables	Failure n = (%)	No Failure n = (%)	*p*-Value
Cardiovascular disease (Hypertension)	4 (14.8%)	23 (85.2%)	0.999
Periodontal disease	3 (4.5%)	64 (95.5%)	0.920
Allergy to drugs	1 (4%)	24 (96%)	0.0001 *
Smoking habits			
<10 c/day	1 (5.9%)	16 (94.1%)	0.953
>10 c/day	1 (3.8%)	25 (96.2%)	

(*): statistically significant result.

Table 6. Association between implant location, regeneration, and type of implant failure.

Implant Variables	Failure n = (%)	No Failure n = (%)	*p*-Value
Location			
Maxilla	6 (2.7%)	219 (97.3%)	0.417
Jaw	3 (1.5%)	194 (98.5%)	
Location			
Anterior	7 (4%)	169 (96%)	0.014 *
Posterior	2 (0.8%)	244 (99.2%)	
Regeneration	5 (8.5%)	54 (91.5%)	0.098
Type of failure:			
Early	6 (66.7%)	0 (0%)	0.0001 *
Late	3 (33.3%)	0 (0%)	
Type of failure related to implant position			
Anterior/early	6 (3.4%)	169 (96%)	
Anterior/late	1 (0.6%)		0.027 *
Posterior/early	0 (0%)	244 (99.2%)	
Posterior/late	2 (0,8%)		

(*): statistically significant result

The 373 implants with a prosthetic load record (excluding the 4 implants explanted after 199, placing the prosthesis) are currently functional.

Table 7. Clinical characteristics of the failed implants. Dis: Disease; HTN: Hypertension; A: Penicillin, Tetracyclines, Streptomycin, Erythromycin, Lincomycin, Gentamicin, Sulfamethoxazole, Epinephrine, Chlorhexidine, Cobalt chloride and nickel chloride; S: Sulfamides; B: Bruxism; L: Location; D: Diameter; H: Height; PE: Post-extraction; F: Fibrointegration; VF: Vestibular fenestration; IR: Implant redirection.

Case No.	Gender	Age	Parafunctional Habits	Autoimmune Dis.	Osteoporosis	Bisphosphonates	Diabetes	Cardiovascular Dis.	Periodontal Dis.	Allergy to Drugs	Smoking Habit	L	D	H	Surgery	Regeneration	Reason for Failure/Type of Failure
1	M	43	No	No	No	No	No	No	No	No	No	1.3	3.8	12	Delayed	-	F (4th week)
2	M	56	No	No	No	No	No	No	Yes	S	<10 cig./day	1.2	3.8	12	Delayed	-	F (4th week)
3	F	67	No	No	No	No	No	No	No	A	No	3.2	3.8	10.5	Delayed	Bios oss® Bio guide®	VF. Associated symptomatology (8th week)
4	M	36	No	No	No	No	No	HTN	No	No	No	3.6	3.8	9	Delayed	-	IR (8 months post-load)
5	M	50	No	No	No	No	No	No	Yes	No	No	2.6	4.6	12	Delayed	Simultaneous sinus lift	Pain, mobility, and bone loss (4 months post-load)
6	M	50	B	No	No	No	No	HTN	Yes	No	>10 cig./day	2.4	3.8	9	Delayed	-	Implant mobility during prosthetic measurements (5 months)
7	F	59	No	No	No	No	No	No	No	No	No	2.3	3.8	12	PE	Bios oss® Bio guide®	Implant mobility, VF (2 weeks immediate post-load)
8	F	74	No	No	No	No	Type 2	HTN	No	No	No	3.4	3.4	12	Delayed	-	F (8th week)
9	M	82	No	No	No	No	No	HTN	No	No	No	2.3	3.8	12	PE	Yes	Mobility and percussion pain during prosthetic measurements (5 months)
(p = value)	0.337	0.403	0.762	0.982	0.699	0.904	0.915	0.999	0.920	<0.0001	0.953	0.417/0.027				0.098	<0.0001

4. Discussion

This cohort study conducted during the Master of Medicine, Surgery, and Oral Implantology course at the University of Barcelona on 192 patients treated with Biohorizons® dental implants concluded a 2.13% failure rate, in line with the percentages found in the literature [28,29], with a 97.87% survival rate across a range of 6 months to 3 years, a figure within the values established by most previous works. However, other investigations exposed higher failure rates in postgraduate students, between 3.9% and 16% [27,29].

The results found statistically significant values for implants that failed early ($p < 0.0001$), coinciding with some authors, who stated that the early failure rate is greater than the late failure rate [30,31]. This type of failure is attributed to the first phase of treatment, which covers variables such as patient condition, surgeon experience, the type of surgery, and post-operative care. The main causes include periodontal disease, smoking habit, surgical complications, surgeries at the same time as bone regeneration, a lack of primary stability, infections, high healing abutments, and immediate loads on occlusion [32,33]. However, these variables were not significant in our study; this may be due to the percentage of the sample that presented the evaluated risk factors, unlike research with larger sample sizes.

Implant failures relating to location on the arch did present statistically significant differences between the anterior/posterior sector and association with early failure, $p = 0.027$ and $p = 0.014$, respectively. There is no concordance between the prevalence of failure of implants based on location. There are studies to support the theory that the superior maxilla, on being a more porous bone and easier to reabsorb, presents more implant losses than the mandible [34,35]. As opposed to other investigators who explained that a higher failure rate occurs in the mandible region over the short-term, this is down to the cortical thickness and limited mandible vascularization [9].

Among the factors studied in this study, no statistically significant differences were presented regarding patient gender. The average age (54.5 $\pm$ 13 years old) is similar to the age in other retrospective studies conducted in universities with an average age of 54.4 years old [3,29,36], given that it corresponds to the patterns of incidence and prevalence when more tooth loss starts to occur [37].

As was already stated, the patient's systemic condition and habits play a key role in the survival of implants over the short- and long-term. No significant differences were found between bruxism and implant failure. Although this study showed that patients with a history of periodontal disease did not present a higher level of implant failure compared to patients without a history of periodontal disease, studies with a larger sample size have suggested that periodontal disease is a risk factor for implant failure [21,22]. Our study did not find any statistically significant differences between patients that smoked <10/>10 cigarettes a day with implant failure and survival. However, investigation over time indicates a high risk of failure among patients with a frequency of over 15 cigarettes a day [3,38]. Currently, studies have shown that patients allergic to penicillin present higher early implant failure due to a lack of osseointegration and infection due to the effects of clindamycin on bone cells [39,40]. Although the results regarding patients allergic to penicillin were significant in our study, they should be treated with caution as the same patient presented allergy to all the studied drugs.

As was already mentioned, bone regeneration is classified as a risk factor [12,14]. The survival rate at 5 and 10 years for implants placed in regenerated regions drops from 90% to 79% compared to implants placed in native bone [41]. Our investigation presented a greater loss of implants when they were placed in combination with regenerative procedures, but without statistical significance (N = 5, with $p = 0.098$). Evaluating this risk factor in isolation is difficult, as other factors are in play that when taken in combination, leading to a worse prognosis of success and survival for implants. These include the patient's systemic condition and smoking habit [24].

A total of 63.74% of implants were loaded late ($\geq$6 months), with a fixed prosthesis the most used type, N = 338 (80.09%), while only 8.29% of implants N = 35 were used for mandible crowns. These data appear reasonable if we consider the average patient age. The

study conducted by Balarezo et al. (2019) showed that there is a direct relationship between age and prosthesis type, whereby the frequency of single crowns and fixed prostheses was higher among patients aged 40 to 60 years old as the patients seen were mostly partially edentulous patients [42].

Being a retrospective study, one of the limitations was the possible bias during data collection, which was registered and validated by different researchers. Another limitation was not clinically evaluating each patient to corroborate the data obtained from the medical history. The nature of our study prevented us from studying some variables not described in the present investigation, such as drug abuse [43], use of probiotics, hyaluronic acid [44], and aloe vera [45], which can modify the clinical and microbiological parameters and influence the stability of the implant. All these variables should be considered in future clinical trials.

5. Conclusions

This study obtained a respective survival and failure rate of 97.87% and 2.13% for implants placed by students on the Master of Medicine, Surgery, and Oral Implantology course at the University of Barcelona over a period of 6 months to 3 years. The results showed that the survival and failure rates of implants placed by postgraduate students are similar to those obtained by experienced professionals, being an effective and predictable therapy for partially or edentulous patients.

Compared to late failure, early failure presented statistically significant differences of $p < 0.0001$. Additionally, there was a statistically significant association in the failure of implants in the anterior sector compared to the posterior sector, $p < 0.027$, and with early failure, $p < 0.014$.

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Conflicts of Interest: The authors state that this is an original work with no conflict of interest with any company.

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