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ORIGINAL ARTICLE

Implant survival in the anterior mandible: A retrospective cohort study

Ignacio Pedrinaci[1,2] | Teresa Chanting Sun[3,4] | Mariano Sanz-Alonso[2,5] | Javier Sanz-Esporrin[2,5] | Adam Hamilton[1,6] | German O. Gallucci[1]

[1]Department of Restorative Dentistry and Biomaterials Science, Harvard School of Dental Medicine, Harvard University, Boston, Massachusetts, USA

[2]Section of Graduate Periodontology, School of Dentistry, University Complutense, Madrid, Spain

[3]Department of Periodontology, School of Dentistry, National Defense Medical Center and Tri-Service General Hospital, Taipei, Taiwan

[4]Department of Periodontology, Mackay Memorial Hospital, Taipei, Taiwan

[5]ETEP (Etiology and Therapy of Periodontal and Peri-implant Diseases) Research Group, University Complutense, Madrid, Spain

[6]Division of Oral Restorative and Rehabilitative Sciences, University of Western Australia, Perth, Australia

Correspondence
German O. Gallucci, Department of Restorative Dentistry and Biomaterials Science, Harvard School of Dental Medicine, Harvard University, Boston, MA, USA.
Email: german_gallucci@hsdm.harvard.edu

Abstract

Objective: This study aims to report the implant survival rate of dental implants of partially dentate patients in the anterior mandible and the potential risk indicators for implant failure.

Materials and Methods: Patients with implant-supported restorations of single or multiple teeth in the anterior mandible restored with fixed partial implant-supported restorations were evaluated. Patient demographic data, implant placement timing, and loading protocol, biological and/or technical complications at the time of the last clinical and radiographic follow-up visit were registered. Survival rate, success rate, and potential risk indicators for implant failure were calculated.

Results: A total of 108 patients and 186 implants with a mean follow-up period of 5.48 years (0.1–11.34 years) were included. The 11.3-year cumulative survival rate was 90.9%. Immediate implant placement (OR = 2.75) ($p = .08$) and immediate implant loading (OR = 8.8) ($p = .02$*) indicated a higher risk of failure than late implant placement or loading. When combining both categories (type 1A), an OR = 10.59 ($p = .04$*) for implant failure was found compared to category 4C. Implants placed following static—computer-assisted implant surgery (S-CAIS) showed less risk of failure compared to freehand implant placement (OR = 0.18; 95% CI: 0.02–1.37) ($p = .09$).

Conclusions: The survival rate of implants placed in the anterior mandible was considerably low (90.9%). S-CAIS, late placement, and conventional loading are protective factor against implant failure in the anterior mandible.

KEYWORDS
computed assisted surgery, conventional implant loading, implant failure, late implant placement, mandible, risk indicators, survival rate

1 | INTRODUCTION

The anterior mandible due to its inherent anatomical and structural characteristics frequently leading to pronounced resorption patterns after tooth extraction represents a unique area in the oral cavity for the placement of dental implants. Its characteristic dense cortical bone (D1, Misch, 1990) and the three-dimensional ridge configuration consequence of tooth loss may significantly influence the placement of dental implants and their subsequent clinical performance (Gallucci et al., 2017). Therefore, the treatment planning

for implant placement and prosthetic loading should starts even before the tooth is extracted once it is considered as hopeless (Morton et al., 2018).

Several factors related to the anatomy of the anterior mandibular region may have a profound impact when replacing teeth with dental implants, such as: (1) the roots of the lower incisor roots are narrow in the cervical aspect and the direction of their long axis is frequently different to the desired ideal implant position; (2) the alveolar bone three-dimensional configuration and its highly cortical bone composition may difficult primary implant stabilization and frequently requires simultaneous bone regenerative interventions (Couso-Queiruga et al., 2022); (3) the thin gingival phenotype and reduced thickness of the buccal bone plates may enhance bone resorption after tooth extraction (Couso-Queiruga, Stuhr, et al., 2021); (4) the high functional requirements in this areas, such as the tongue push during phonetics and mastication that generates non-axial loading forces (van Eijden, 1991); (5) the high esthetic demand in some individuals (Hof et al., 2014); (6) the presence of anatomical limitations such as the mandibular incisive canal, lingual foramen, and anterior looping of the mental nerve (Mraiwa et al., 2003; Pereira-Maciel et al., 2015).

In general terms, dental implants present high long-term survival rates (Chrcanovic et al., 2016; Derks et al., 2015; Friberg & Jemt, 2015; Pjetursson et al., 2012), but a recent systematic review aimed to evaluate single implants in different locations reports lack of data on the anterior mandible of partially edentulous patients (Zhou et al., 2021) and when reporting overall data, there is scarce information specifically focused on the anterior mandible (Becker et al., 2011; Bianchi & Sanfilippo, 2004; Velasco-Ortega et al., 2018). There is, however, a general feeling among clinicians that tooth replacement in this region is a straightforward procedure. This conception proceeds from the rehabilitation of full edentulous patients where the physiological resorption process has occurred and the remaining mandibular basal bone represents a favorable site for implant placement.

Considering this conflicting information and the lack of data associated with this specific anatomical area, the objective of this study is to report the survival rate of dental implants placed in the anterior mandible of partially edentulous patients and evaluate the potential risk indicators associated with implant failure.

2 | MATERIALS AND METHODS

2.1 | Experimental design/sample

This investigation was designed as a retrospective case series study and was conducted in compliance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Vandenbroucke et al., 2007; von Elm et al., 2007). The patient's and implant-related data were obtained from the electronic health records of all patients treated at Harvard School of Dental Medicine since 2009.

2.2 | Ethical approval and registration

Ethical approval was obtained from the Office of Human Research Administration at the Harvard Medical School (IRB17-1026).

2.3 | Eligibility criteria and recruitment

The following criteria were used to select data from adult patients contained in this database: (1) single tooth implants in the anterior mandible (i.e., lower incisors and canines areas) restored with single crowns; (2) implants for replacing multiple missing teeth in the anterior mandible restored with fixed implant-supported restorations; and (3) implants with clinical and radiographic records of at least 6-month follow-up unless an early failure occurred, in which case the failure was included in the analysis. Cases were excluded if: (1) Implants placed in other locations outside of the anterior mandible (i.e., maxillae, mandibular premolar, or molar areas); (2) implant placed within the anterior mandible region but planned to be restored with a prosthesis extending outside of the anterior mandible zone (#33-#432); (3) implants planned to be restored with an overdenture or implant-supported fixed full arch structure.

TABLE 1 Summary of the sample characteristics.

Variable (patient related)	*N* (%)
Total (patient)	108
Gender	
Male	67 (62.03)
Female	41 (37.96)
Age	
≤30	5 (4.62)
31–50	29 (26.85)
51–70	49 (45.37)
≥71	25 (23.14)
Smoking status	
Non-smoker	61 (56.48)
Ex-smoker	37 (34.25)
Smoker ≤10/day	10 (9.26)
Smoker >10/day	0 (0)
Systemic disease	
Obesity (BMI > 25)	45 (41.67)
Diabetes (type 1 or 2)	12 (11.11)
Hypertension	38 (35.19)
Cardiovascular disease	16 (14.81)
Osteoporosis	6 (5.56)
Arthritis	4 (3.70)
Healthy without any medical condition	18 (16.67)

TABLE 2 Summary of the implant characteristics.

Variable (implant related)	*N* (%)
Total (implant)	186
Implant diameter	
≤3.3 mm	128 (68.8)
3.3–4.1 mm	13 (7.0)
≥4.1 mm	42 (22.6)
Lack of information	3 (1.6)
Implant length	
≤10 mm	101 (54.3)
> 10 mm	83 (44.6)
Lack of information	2 (1.0)
Implant manufacturer	
Straumann	157 (84.4)
Nobel	28 (15.0)
Other	1 (0.5)
Position in arch	
#22	36 (19.4)
#23	38 (20.4)
$24	18 (9.7)
#25	15 (8.1)
#26	46 (24.7)
#27	33 (17.7)
Implant prosthetic design	
Fixed partial denture	136 (73.1)
Single crown	37 (19.9)
Failed before loading	13 (7.0)
Prosthesis retention type	
Screw-retained	71 (38.2)
Cement-retained	82 (44.0)
Hybrid	4 (2.2)
Unknown	29 (15.6)

2.4 | Outcome variables

To minimize missing data two researchers (IP, TS) retrieved the records and collected the data independently. The following information was collected: (1) patient's age at the time of implant placement; (2) gender; (3) presence of any systemic disease; (4) history of smoking; (5) history of periodontal disease; (6) implant location; (7) computer-assisted implant placement (Yes/No); (8) type of implant prosthesis; (9) prosthesis retention type; (10) date of final prosthesis delivery.

Implant survival, defined as the presence of the implant in the oral cavity independent of having biological and/or technical complications at the time of the last clinical and radiographic follow-up, was assessed longitudinally (from July 21, 2009, to September 24, 2019).

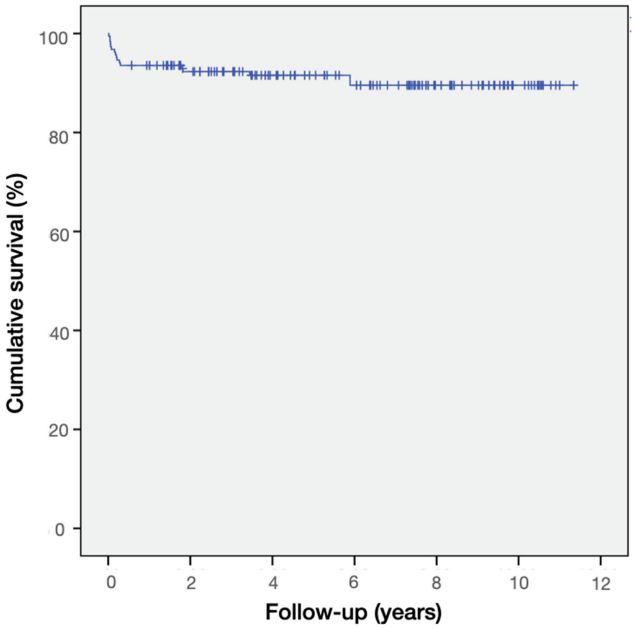

FIGURE 1 The cumulative survival rate of implant at 11.3 years. Vertical lines represent the follow-up time of each implant.

Implant failures were registered based on the following classification: (1) Early implant failure (EIF) in presence of pain, infection, peri-implant radiolucency, or implant mobility within the first 6 months after implant placement or (2) Late implant failure (LIF) when any of the previously described clinical or radiographic signs occurred after the first 6 months after implantation (Staedt et al., 2020).

Successful implants were considered when complications had not been identified based on the following criteria: (1) absence of clinically detectable implant mobility; (2) absence of pain and any other subjective unpleasant feeling; (3) no peri-implant radiolucency after loading; (4) no signs of peri-implantitis or recurrent peri-implant mucositis (Berglundh et al., 2018).

Depending on the implant placement protocol cases were categorized as: immediate placement (type 1), early placement (types 2–3), and late placement (type 4) (Chen & Buser, 2009; Gallucci et al., 2014). Also depending on the implant loading protocol cases were categorized as immediate loading/restoration (type A), early loading (type B), and conventional loading (type C) (Gallucci et al., 2014; Weber et al., 2009). Statistical analysis was also performed combining implant placement and loading protocol (Gallucci et al., 2018).

2.5 | Statistical analysis

Descriptive data were reported as means and standard deviations for quantitative variables, while frequency distributions and cross-tabulations were used for categorical variables. Kaplan–Meier analysis was performed to evaluate the cumulative survival rates. Using implant failure as the outcome, a regression analysis model was

TABLE 3 Characteristics of patients, implants, type of restorations and timing of the failing implants.

Patient No.	Gender	Age at time of implant placement	History of smoking	Implant location	Implant prosthetic design	Type of retention	Implant placement protocol	Implant loading protocol	Follow-up (days) between implant placement and failure
1 (50)	M	38	No	23	Bridge	Cement-retained	Type 1	C	665
1 (50)	M	38	No	26	Bridge	Cement-retained	Type 1	C	658
2 (36)	M	53	Ex-smoker	24	Bridge	Screw-retained	Type 4	A	16
2 (36)	M	53	Ex-smoker	26	Bridge	Screw-retained	Type 4	A	16
3 (10)	M	47	No	26	No	No	Type 4	None	57
4 (12)	M	75	No	24	No	No	Type 1	None	22
5 (17)	F	42	No	24	No	No	Type 1	None	65
6 (18)	M	78	No	25	No	No	Type 1	None	73
6 (18)	M	78	No	25	No	No	Type 2–3	None	78
7 (30)	M	59	Ex-smoker	27	No	No	Type 1	None	108
8 (40)	F	68	No	22	No	No	Type 2–3	None	2152
8 (40)	F	68	No	22	No	No	Type 2–3	None	2152
9 (59)	M	57	Ex-smoker	22	No	No	Type 4	None	28
10 (89)	F	49	Ex-smoker	22	No	No	Type 1	None	20
11 (106)	F	72	Ex-smoker	22	No	No	Type 4	None	5
12 (107)	M	40	Smoker (<10/day)	24	No	No	Type 4	None	1260
13 (108)	M	67	Ex-smoker	23	No	No	Type 4	None	100

TABLE 4 Summary of the type of implant placement, loading protocols, and its combinations.

	Loading protocol			
Total number of implants (N = 186)	**Immediate loading (Type A)**	**Early loading (Type B)**	**Conventional loading (Type C)**	**No loading**
Number of implants	7 (3.8%)	5 (2.7%)	161 (86.56%)	13* (6.99%)
Number of failures	2 (11.8%)	0 (0%)	7 (41.2%)	8 (47.1%)
Implant placement protocol				
Immediate placement (type 1)	Type 1A	Type 1B	Type 1C	
Total: 43 (23.1%)	/	/	38 (20.4%)	5 (2.7%)
Failures: 7 (41.2%)	/	/	4 (23.5%)	3 (17.64%)
Early placement (types 2–3)	Type 2–3A	Type 2–3B	Type 2–3C	
Total: 37 (19.9%)	/	3 (1.6%)	32 (17.2%)	2 (1.08%)
Failures: 3 (17.6%)	/	0 (0%)	2 (11.8%)	1 (5.88%)
Late placement (type 4)	Type 4A	Type 4B	Type 4C	
Total: 106 (57%)	7 (3.8%)	2 (1.1%)	91 (48.9%)	6 (3.22%
Failures: 7 (41.2%)	2 (11.8%)	0 (0%)	1 (5.9%)	4 (23.53%)

Note: *p*-Value indicates statistically significant differences in: loading protocol ($p \leq 0.01$) and combination of loading and type of implant placement ($p < 0.01$), while type of implant placement ($p = 0.21$) showed non statistically significant differences. Type 1, immediate; Type 2 and 3, early; Type 4, late implant placement. Loading A, immediate; loading B, early; loading C, late implant loading; No Loading, restorations were not yet placed or implant failure before loading.

*Out of these 13 no loading implants, eight failed before loading and five did not have any loading information at the time of record review.

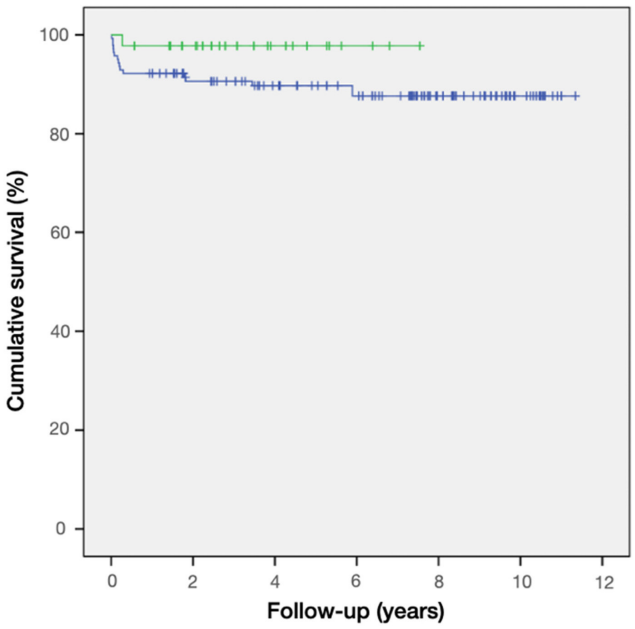

FIGURE 2 The cumulative survival rate of implant is distributed according to the guided implant protocol. Green line represents guided implant placement SCAIS and blue line non-SCAIS.

constructed to evaluate existing risk indicators at patient, implant, and prosthetic level. Chi-square tests were performed to assess the statistical significance between these factors associated with implant failure. All data analyses were performed using a dedicated software (SPPS® 20.0, SPSS Inc.). The level of statistical significance was set at 5% ($p < .05$).

3 | RESULTS

3.1 | Sample characteristics

From a total of 255 patients initially identified with dental implants in the anterior mandible, 108 were finally included after filtering for the previously referred inclusion and exclusion criteria. This final sample consisted of 108 patients, 68 males (63%), and 40 females (37%) with a mean age of 63 ± 16.1 years (range: 20–94 years). These patients had 186 dental implants placed in the mandibular anterior region (#22 - #27) and were followed from July 21, 2009, to September 24, 2019, with a mean follow-up period of 5.48 years (0.1–11.34 years).

The demographic characteristics of the patients including age, gender, and presence of medical conditions are reported in Table 1. A history of periodontal disease was confirmed in 70 subjects (64.8%).

3.2 | Implant characteristics

The implant and prosthetic characteristics are reported in Table 2. Most implants were placed as part of a fixed partial restoration to replace multiple missing mandibular anterior teeth (73%). Lateral incisors (45.1%) or canines (37.1%) were more frequent implant sites than central incisors (17.8%). Seventy-one implants corresponded to a screw-retained restoration (38.2%) while 82 (48.0%) were included in cemented restorations and 4 (2.2%) in cement retained with direct screw access. In 29 implants (15.6%) there was

TABLE 5 Implant failure predictors.

Predictors	Total number of implants	Failures	OR	*p*	95% CI
Smoking (Ref: NS)					
Non-smoker	59	9			
Ex-smoker	36	7	1.35	.56	0.477–3.842
Smokers <10 cig/day	9	1	0.74	.78	0.088–6.347
Smokers >10 cig/day	1	0	0.00	.99	0.000–0.000.
Gender (Ref: male)	68	12	0.73	.58	0.248–2.19
H° of Perio Disease (Ref: non-Periodontitis)	35	15	3.35	.12	0.74–15.21
Systemic disease (Ref: Healthy)	45	9	0.91	.85	0.334–2.46
Timing of implant placement (Ref: type 4)					
Type 1	43	7	2.75	.08	0.54–11.43
Types 2 and 3	37	3	1.25	.76	0.456–3.465
Type 4	106	7			
Loading protocol (Ref: C)					
A	7	2	8.8	.02*	1.75–16.654
B	5	0	0	.99	0.000–0.000
C	161	7			
None	13	8	35.2	.000	5.75–54.765
Combined protocol (Ref: 4C)					
1C	38	4	10.59	.04*	2.68–29.765
2–3B	3	0	0	.99	0.000–0.000
2–3C	32	2	6	.15	0.345–15.367
4A	7	2	36	.01*	6.35–55.663
4B	2	0	0	1	0.000–0.000
4C	91	1			
No Loading	13	8	144	.0	54.56–256.45
Guided Implant placement (Ref: non-guided)	45	1	0.18	.09	0.023–1.378

Note: Type 1, immediate implant placement; Types 2 and 3, early implant placement; Type 4, late implant placement. Loading A, immediate loading; B, early loading; C, late implant loading; No Loading, restorations were not yet placed or implant failure before loading.

Abbreviation: OR, Odd Ratio.

*Statistically significant ($p < .05$).

no information on the type of retention. A total of 128 (68.8%) implants have a diameter of ≤3.3 mm and 42 (22.6%) implants were ≥4.1 mm.

3.3 | Implant survival

The 11.3-year cumulative survival rate of implants placed in the anterior mandible assessed by Kaplan–Meier analysis was 90.9%. The estimated average of survival was 10.76 years (95% CI: 9.8–10.7).

Figure 1. Represents the cumulative implant survival rate curves.

3.4 | Implant failure

From a total of 17 failed implants, 12 failed were EIF and two failed between 6-month and 2-year follow-up. The remaining three implants failed at: 3.4, 5.8, and 5.8 years after the implant placement, respectively. Implant failure distribution was as follows: 12 (79.6%) on males and 5 (29.4%) on females. Only one of these failures was associated with a smoker patient of less than 10 cigarettes/day (5.9%), being the rest (16) associated with non-smokers or ex-smoker patients (94.1%). Fifteen failures (88.2%) occurred in patients with a history of periodontitis. Similarly, nine implant failures (52.9%) corresponded to patients with a systemic disease, while eight (47.1%) occurred in healthy patients. The characteristics of patients, implants, and type of restorations associated with the failed implants are summarized in Table 3.

3.5 | Implant success

From the 169 implants present at the follow-up visit, none demonstrated the presence of a peri-implant radiolucency or marginal

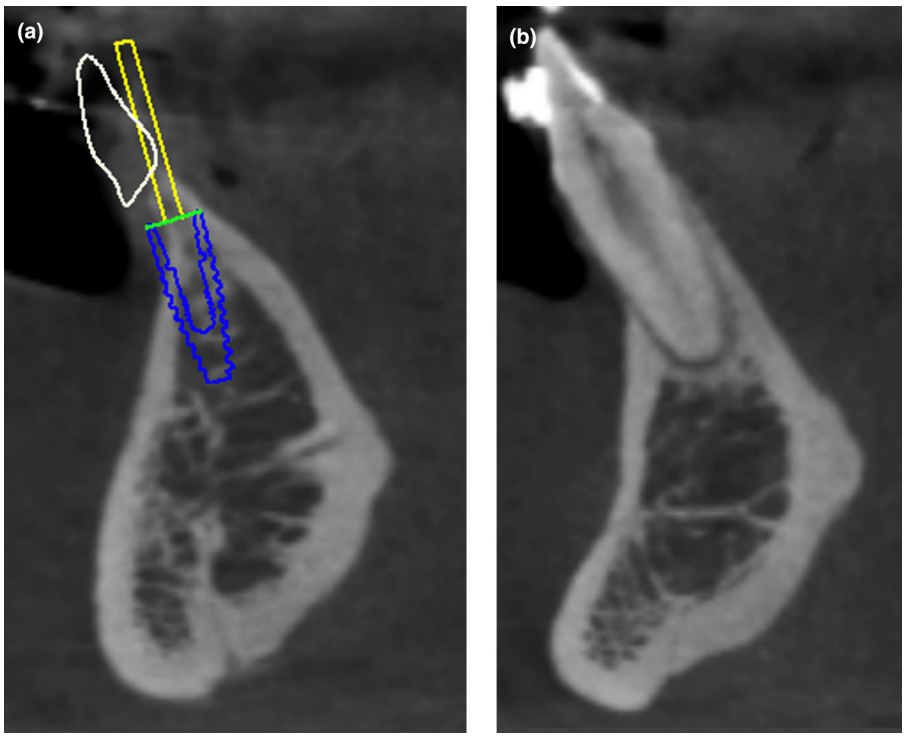

FIGURE 3 CBCT images of a mandibular lateral incisor (a) and central incisor (b) of the same patient which depicts the thin bucco-lingual bone at the crest of the ridge in edentulous sites and facial bone which appears absent around a mandibular incisor. The cortical bone is very thick and shapes of the mandibular basal bone in both sites are distinctly different.

bone loss. Furthermore, the clinical records did not show any case of implant mobility, pain, or the presence of any other peri-implant disease. As such, the success rate according to the defined success criteria was 90.9%.

3.6 | Type of implant placement and loading protocols

Most of the failures (eight implants; 47.1%) occurred in implants prior to prosthetic loading, while seven (41.2%) occurred in conventionally loaded implants (type C) and two (11.8%) in type A loading. No failures were found in type B. In relation to implant placement protocols, seven implants (41.2%) corresponded to types 1 and 3 (17.6%) to types 2 and 3 and 7 (41.2%) to type 4 ($p = .20$).

Distribution of the type of implant placement protocol, loading protocol, and its combinations are provided in Table 4. None of the differences were statistically significant.

3.7 | Static - computer-assisted implant surgery

Forty-five implants (24.2%) were placed following an S-CAIS protocol while 141 (75.8%) were placed free-hand. Sixteen failed implants (94.1%) corresponded to the non-computer-assisted surgery group, while one (5.9%) was placed under computer-assisted modality ($p = .06$). The cumulative survival rate of implants placed under a computer-assisted approach assessed by Kaplan–Meier analysis was 97.8% (95% CI: 7.06–7.69) while the cumulative survival rate in the non-computer-assisted group was 88.7% (95% CI: 9.57–10.69), being these differences close to statistically significance ($p = .08$).

Figure 2 represents the cumulative survival rate graphic according to the computer-assisted surgery protocol.

3.8 | Potential risk indicators for implant failure (regression analysis)

Risk predictors for implant failure are depicted in Table 5. Implants placed following an S-CAIS protocol had a lower chance of failure in the anterior mandible (OR = 0.18; 95% CI: 0.02–1.37). When compared to a free-hand procedure, SCAIS had 5.55 less odds of failure ($p = .09$). Immediate implant placement (OR = 2.75) ($p = .08$) and immediate implant loading (OR = 8.8) ($p = .02$*) also had a higher risk of failure than late implant placement or loading. When combining both categories, immediate implant placement with immediate loading (1A category and compared to 4C category), this higher risk of implant failure increased (OR = 10.59 [$p = .04$*]). Similarly, late implant placement with immediate loading (4A category) had an OR = 36 ($p = .01$*) for implant failure compared to category 4C (Table 5).

4 | DISCUSSION

The present retrospective case series observational study was aimed to evaluate the performance of implants in the anterior mandible of

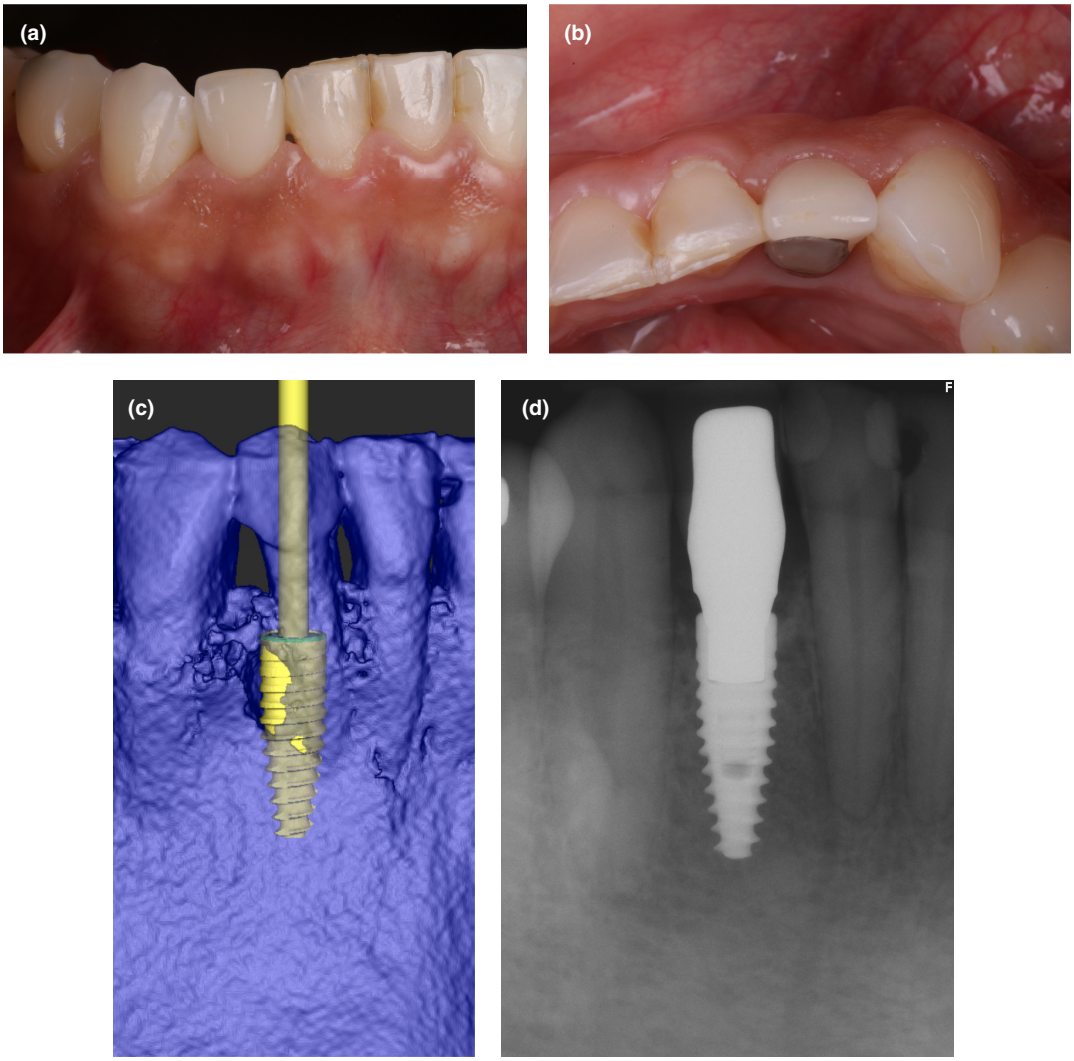

FIGURE 4 Single tooth replacement in the anterior mandible with dental implants as depicted in this patient is often challenging due to reduced mesiodistal tooth dimensions and the proximity of adjacent tooth roots.

partially dentate patients and the potential risk indicators associated with implant failure in this anatomical location. The 11.3 years cumulative survival rate resulted in 90.9% which is difficult to compare with the existing scientific evidence considering the scarcity of studies reporting specific data on implant survival in the anterior mandible in partially edentulous patients. A recent systematic review (Zhou et al., 2021) reported a weighted mean survival rate of 98.5%–100% for a total of 42 implants corresponding to the anterior mandible, although none of the three studies reporting data on the anterior mandible (Becker et al., 2011; Bianchi & Sanfilippo, 2004; Velasco-Ortega et al., 2018) were specifically designed to evaluate exclusively this region. These high survival rates reported in this systematic review are similar to another systematic review (Howe et al., 2019) assessing a 10-year implant survival rate considering implants placed in all areas of the mouth, reporting 96.4% (95% CI 95.2%–97.5%).

When comparing our results with those reported in the mentioned systematic reviews (Howe et al., 2019; Zhou et al., 2021), the 90.9% cumulative survival rate at 11.3 years of implants placed in the anterior mandible may be considered as lower. The explanation for these results may be due to the specific characteristics of the partially edentulous anterior mandible. Unlike the anterior maxilla, mandibular incisors exhibited the smallest mean root volume and surface (Couso-Queiruga, Ahmad, et al., 2021). This anatomic consideration results in a reduced buccolingual and mesiodistal dimension of the alveolar ridge after extractions, what determines the lack of space for an ideal peri-implant bone thickness (Monje et al., 2019). This fact becomes particularly remarkable in some specific mandible shapes where there is a little margin of error and therefore the planning phase seems to be extremely relevant to obtain an ideal implant position (Wright et al., 2020). Furthermore, anterior mandible is characterized by a dense cortical type 1 bone with a reduced vascularity (Lekholm, 1985), what could affect the osseointegration process (Figure 3).

Furthermore, mandibular anterior teeth are the least common to be replaced with dental implants (Elani et al., 2018; Zhou et al., 2021). In this study, the sample consisted of 19.9% for single tooth restorations (Figure 4), versus 73.1% for restoring multiple teeth (Figure 5) in partially edentulous patients. Given the anatomical and prosthetic

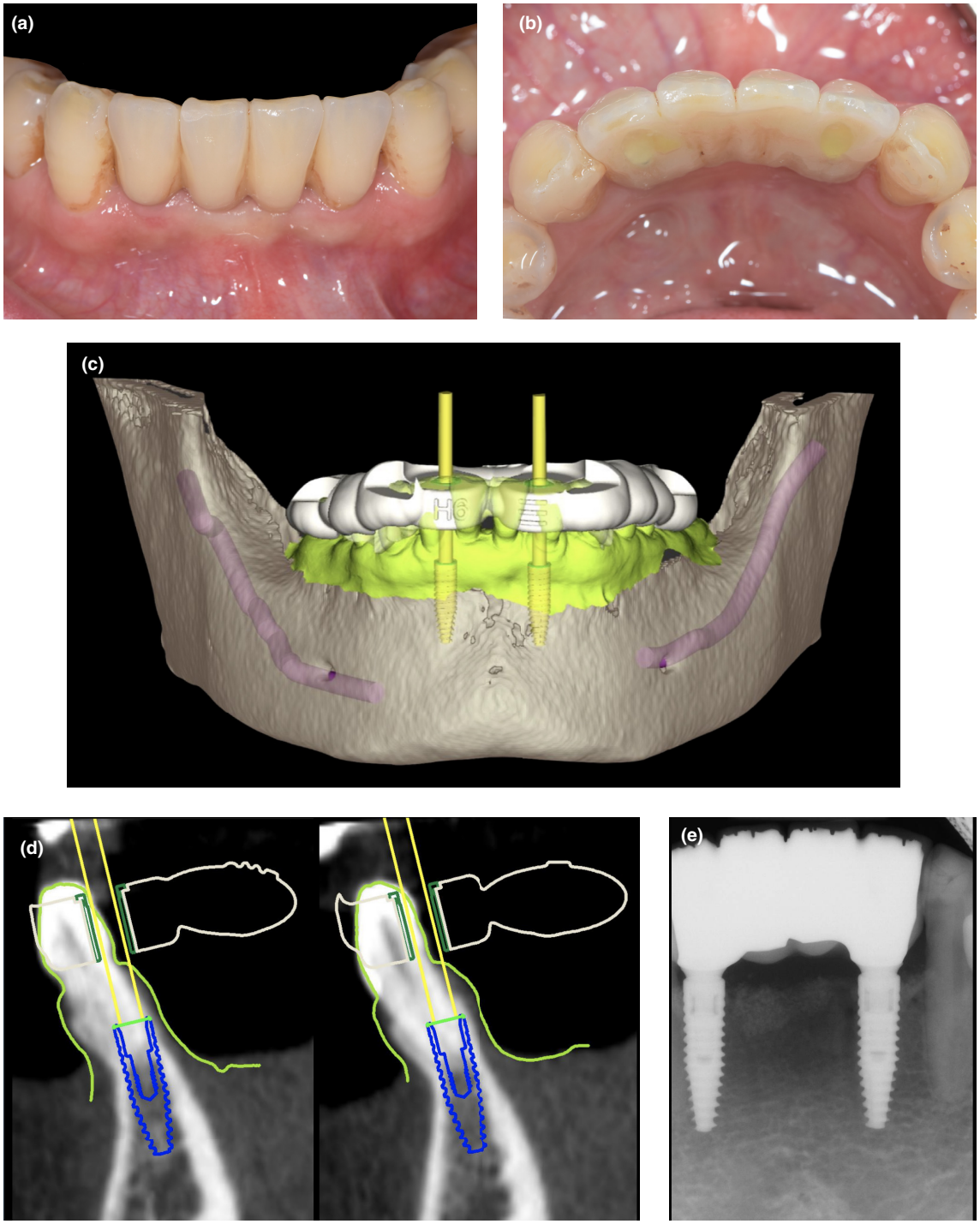

FIGURE 5 Fixed partial dentures replacing all four lower incisors such as in this patient were the most common presentation.

challenges of replacing a single mandibular incisor, the condition of the adjacent mandibular anterior teeth often needs to be considered for treatment planning purposes.

In the reported sample, the central incisor location was also the least common site for implant placement (17.8%) which may be associated with it being the narrowest tooth in the mouth (Couso-Queiruga, Ahmad, et al., 2021). The mesiodistal width of lower incisors is often inadequate for single-tooth implant replacement due to the required prosthetic space which may compromise the esthetic and functional outcomes. Similarly, this reduced space is often inadequate to provide the recommended mesiodistal biological width between the adjacent roots and a dental implant. Thus, maintaining the interproximal bone peaks and subsequent anatomical papillae is more challenging. On the contrary, the reduced mesiodistal width can be an advantage for considering a cantilever resin bonded bridge. Together with the presence of tall adjacent teeth with adequate enamel for bonding, the resin bonded bridge may be the most suitable treatment option for replacement of single missing mandibular incisors.

The understanding of the physiological process of bone remodeling after tooth extraction (Araújo & Lindhe, 2005; Avila-Ortiz, Gubler, et al., 2020; Cardaropoli et al., 2005; Discepoli et al., 2013) and a comprehensive three-dimensional assessment of the recipient site before implant placement (Bornstein et al., 2017; Correa et al., 2014) is recommended to assess the availability of an adequate ridge and minimize the risk of associated complications. Interestingly, the data in the present study demonstrated that S-CAIS is an effective tool to reduce implant failure in the anterior mandible (OR = 0.18; 95% CI: 0.02–1.37). Thus, 5.55 less odds of implant failure were shown when following an S-CAIS protocol versus free hand implant placement, and this difference was nearly statistically significant. However, our perception is that guided osteotomy is not the reason for these results, but the comprehensive digital implant planning (virtual simulation) required for the guided protocol. Thus, implant digital planning is translated into a detailed site evaluation and treatment plan selection (i.e.: surgical and loading protocol). However, it is also understood that experience at both; digital planning and surgical implant placement may be an important outcome variable that must be considered and this information is not described.

Because of the retrospective nature of the study, the inclusion of implants in this study was done based on the fact of being placed on the same area. However, some of the ridges were completely different to others due to its physiological resorption pattern. Regression analysis yielded that immediate implant placement has an OR of 2.75 for higher failure risk than late implant placement ($p = .08$). This may be explained because the recipient site becomes mainly composed by basal bone after tooth extraction and therefore, most of the challenging factors above mentioned are reduced.

Immediate implant loading has an OR = 8.8 for failure risk than conventional implant loading ($p = .02$*). This result may be explained due to the permanent impact of the lower lip and tongue over the implant provisional restoration during chewing or speaking. This situation may impair implant stability during the osseointegration process leading to a lower survival rate. Immediate loading was found to be a risk factor for both immediate implant placement and late implant placement protocols with immediate implant placement and immediate loading (1A category) OR = 10.59 ($p = .04$*) compared to category 4C. Similarly, late implant placement and immediate loading (4A category) had an OR = 36 ($p = .01$*) for implant failure compared to category 4C.

Lastly, most of the implant sample (68.8%) correspond to narrow diameter implants (NDIs) due to an appropriate indication for replacing teeth with reduced anatomical size (i.e., lower incisors). However, according to scientific literature (de Souza et al., 2018; Ioannidis et al., 2015; Jung et al., 2018), we cannot conclude this factor to be a reason for a lower survival of implants.

This study, however, has important limitations due to its retrospective nature and its limited sample size, what may limit the interpretation of both the survival and the risk analysis data and hence, the results should be interpreted with caution and prospective long-term controlled clinical studies to accurately evaluate the real risk factors are required. Furthermore, there was a limited information regarding esthetics and clinical peri-implant parameters, hence limiting the appraisal of peri-implant soft tissues and reporting of peri-implant diseases (Avila-Ortiz, Gonzalez-Martin, et al., 2020) what may limit the reporting in terms of implant success (Papaspyridakos et al., 2012).

5 | CONCLUSION

Whitin the limitations of this study, the following conclusions can be drawn for implants placed in the anterior mandible of partially edentulous patients:

- The resulted survival implant rate for implants placed in the anterior mandible in partially edentulous patients was 90.9%.
- Early implant failure (EIF) was shown to be the dominant type of failure resulting in lower implant survival rates in this region of the oral cavity.
- Immediate implant placement (type 1) showed a higher risk of failure than late implant placement (type 4).
- Immediate loading (type A) had a significantly higher risk of failure than conventional loading (type C).
- Late implant placement (type 4), conventional implant loading (type C), and S-CAIS could be considered as contributors against implant failure.

AUTHOR CONTRIBUTIONS

IP (Concept/Design, Data analysis/interpretation, Drafting article, Critical revision of article, Data collection); TCS (Data collection, Drafting article, Critical revision of article); MS-A (Data analysis/interpretation, Drafting article, Critical revision of article, Approval of article); AH (Concept/Design, Data analysis/interpretation, Drafting article, Critical revision of article); JS-E (Statistics, Data analysis/interpretation, Critical revision of article), GOG (Concept/Design, Data analysis/interpretation, Drafting article, Critical revision of article, Approval of article).

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Ignacio Pedrinaci https://orcid.org/0000-0001-7438-5044
Teresa Chanting Sun https://orcid.org/0000-0001-8851-1152
Javier Sanz-Esporrin https://orcid.org/0000-0003-0859-3149
Adam Hamilton https://orcid.org/0000-0003-1523-1904
German O. Gallucci https://orcid.org/0000-0001-6386-594X

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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