Clinical evaluation of the implant survival rate in patients subjected to immediate implant loading protocols

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Abstract

Background. In the past 20 years, several studies and clinical trials have reported similar results for transmucosal implants as compared to submerged implants. Several advantages of immediate loading have been pointed out, such as the reduction of treatment time, trauma reduction, and immediate esthetic and functional improvements.

Objectives. The main objective of this study was to clinically evaluate the implant survival rate in patients with total rehabilitation via implants that underwent immediate loading in the past 5 years.

Material and methods. A cross-sectional, descriptive, observational analysis was conducted. The implant survival rate for an edentulous maxilla or mandible was assessed with regard to the loading protocol by means of a questionnaire and clinical observation. The study included 103 patients with edentulous jaws rehabilitated with fixed prostheses on implants. Each patient received 4–6 implants. In total, 474 implants were placed. Factors such as the implant survival rate as well as biological and prosthetic complications were evaluated and analyzed statistically.

Results. Of the 474 implants initially placed, 458 were considered osteointegrated and 16 were considered lost, which corresponds to a 96.62% implant survival rate. The most common types of failure were prosthetic fractures (46.2%), peri-implantitis (23.1%) and unscrewing (11.5%) in the first 5 years.

Conclusions. The rate of osseointegration for implants placed under immediate loading was extremely high, in accordance with the previously published studies, which led us to conclude that currently, this is a surgical procedure with a high rate of success and high predictability.

Key words: dental implants, osteointegration, primary stability, immediate loading, micromovements

Introduction

In recent decades, dentistry has undergone enormous and continuous evolution. More than 45 years ago, Brånemark demonstrated the ability of natural bone to accept titanium during the period of bone remodeling, thus giving rise to the concept of osteointegration.[1–5]

Classical protocols proposed that implants should not support loads during osteointegration to avoid micromovements, which are considered one of the main risk factors for osteointegration. Thus, the rehabilitation of edentulous patients was performed through a two-stage surgical system. The implants were submerged in soft tissue for a period of 3 months for the mandible and 5–6 months for the maxilla, allowing healing without any occlusal load. The main disadvantages of this technique were the need for a second surgery to expose the implant and place the prosthetic or healing abutment, and a longer period of edentulousness.[6]

In the past 20 years, several studies and clinical trials have reported similar results for transmucosal implants as compared to submerged implants. According to the researchers, it is not necessary to submerge implants under the mucosa during the healing period, which creates an opportunity for an immediate loading protocol.[7]

The definition of an immediate load has evolved, and the most current one was established in 2008 by Esposito et al.[7] According to this definition, a load is applied to the implant up to 1 week after surgery through a provisional restoration, anatomically similar to the final restoration, which is placed later.[8]

Several advantages of immediate loading have been pointed out, such as immediate esthetic and functional improvements, the exclusion of temporary removable prostheses, the prevention of second surgeries, the preservation of soft tissue anatomy, the reduction of treatment costs, easier hygiene due to the reduced number of implants used, and minimizing the need for grafts, since the patient's bone base is used to the maximum extent possible due to the inclination of implants.[9–11]

On the other hand, greater care is needed in patient selection. Therefore, there are contraindications: cases of uncontrolled diabetes; a weakened immune status; blood dyscrasia; and insufficient bone.[10,12]

According to recent studies, implants placed with an immediate load with fixed full-arch prostheses reach very high success rates after several years of follow-up, both in the post-extraction and healed bone, and both in the maxilla and the mandible.[13]

However, Esposito et al., in their latest Cochrane systematic review of loading protocols, concluded that although in selected patients, immediate loading can be performed successfully, trends indicate that the immediately loaded implants fail more often than those following a conventional protocol.[7] In addition, the authors concluded that the topic of immediate loading in toothless jaws is well documented, unlike in the case of dentulous jaws, for which there is less evidence available.[7]

It is well known that good primary stability of the implant is a key condition for the success of immediate loading. This primary stability is influenced by many factors, including local bone quality and quantity, the macrodesign of the implant and the surgical technique. To assess primary stability, it is sufficient to measure the implant insertion torque value; this parameter is easily accessible and is a determinant of success in osteointegration.[14]

Micromovements are one of the main risks that might prevent successful osteointegration. Micromovements greater than 150 μm can compromise the entire process, resulting in the fibrous encapsulation of the implant.[15]

There is a critical micromotion threshold above which fibrous encapsulation prevails over osteointegration. This critical level, however, is not 0 μm, as might be expected. The tolerated micromotion threshold was defined between 50 and 150 μm. In this range of tolerated micromovements, an initial load on the implant surface can even stimulate the newly formed bone to remodel, accelerating the osteointegration process.[15]

Torque values of 30–40 N·cm were generally chosen as the minimum acceptable values for immediate loading. This minimum torque level is important both to guarantee the osteointegration process and to fix the implant–abutment connections through the union screw.[16]

According to Eliasson et al.[17] and Fisher et al.,[18] technical complications often arise when applying an immediate loading protocol. The most common ones are the fracture of the prosthesis, the loosening of the abutment screws and the adjustments of the contour of the prosthesis.[17,18]

The latter can be explained by gingival healing after surgery, resulting in a space around the pillars. In turn, in the case of a conventional load, impressions are made after the healing period, preventing the appearance of this space.[11]

All these complications are solved by adjusting the prostheses without affecting the results of the procedures. All the variables mentioned above are of high importance to reduce the risk of peri-implantitis.[13]

In view of the above, there is a need to clinically evaluate the implant survival rate in patients with total rehabilitation via implants that underwent immediate loading in the last 5 years.

Material and methods

Study characteristics

This was a cross-sectional, descriptive, observational study based on the completion of a questionnaire, carried out by a single dentist calibrated and approved by the ethics committee of the University Institute of Health Sciences

(Instituto Universitário de Ciências da Saúde – IUCS) in Gandra, Portugal, with the aim of analyzing the osteointegration of the implants loaded immediately on toothless jaws.

Sample characteristics

The target population consisted of patients with edentulous jaws rehabilitated with fixed implant-supported prostheses.

Data collection

A questionnaire was developed. It was administered by a single dentist to avoid the calibration of several stakeholders, between November 2018 and March 2019, with the patients' clinical and formal consent.

The questionnaire was divided into 4 sections:

– participants' personal data – sociodemographic data was acquired for patient characterization; the section included details such as gender, age, risk factors, and the reason(s) for tooth loss;
– characteristics of the rehabilitated area – the obtained information allowed identifying which jaw was rehabilitated and detecting the presence or absence of bone defects;
– surgical characteristics – the parameters covered in this part allowed for the description of factors that were most relevant for treatment in the present study (whether there was a need to perform grafts, the technique used, and the length, diameter and brand of the implants); the osteointegration of the implants was also addressed, identifying how many of them were lost;
– complications – in this section, it was checked whether there were any complications, what they were and when they occurred.

Inclusion and exclusion criteria

The analysis embraced edentulous patients rehabilitated by means of fixed implant-supported prostheses with immediate loading, with a follow-up of up to 5 years.

All patients with incomplete or non-existent clinical information were excluded from the questionnaire.

Statistical analysis

The data obtained in the questionnaire was grouped in MS Excel® (Microsoft Corporation, Redmond, USA) before proceeding to the statistical analysis. All the results were statistically analyzed using IBM SPSS Statistics for Windows, v. 24.0 (IBM Corp., Armonk, USA). Descriptive statistics, appropriate for each variable, were used as well as the analysis of absolute and relative frequencies. The questionnaire referred to qualitative variables; accordingly, the χ^2 test of independence was used. In all the tests, a significance level (α) of 5% was used, i.e., $\alpha = 0.05$. There are some requirements regarding the χ^2 test, without which it cannot be applied. It is assumed that the expected frequencies are higher than 1 and that at most 20% of them are lower than 5. This test presents as a null hypothesis (H0) that the variables are independent; as an alternative hypothesis (H1), the variables are not independent, thus they are related. There is statistical evidence showing that the variables are related when the p-value associated with the test is below the determined significance level, i.e., when the p-value is <0.05. In cases where the χ^2 test of independence could not be applied, classes were grouped so that the test verified the respective assumptions.

Results

To perform this study, a questionnaire was administered. Therefore, this section presents its results.

Sample description

Of a total of 103 participants, 50 (48.5%) were female and 53 (52.5%) were male. Thus, there was a homogeneous distribution of both genders.

Regarding the age distribution (Table 1), the group aged 56–65 years was the largest in the sample with a percentage of 54.4% (n = 56), followed by the group aged 46–55 with a corresponding percentage of 21.4% (n = 22) and the group of participants over 65 years old with a percentage of 19.4% (n = 20). Only 5 persons (4.9%) were under 45 years of age.

Table 1. Distribution by participant age

Age [years]	Frequency *n*	Valid percentage [%]	Aggregate percentage [%]
≤35	1	1.0	1.0
36–45	4	3.9	4.9
46–55	22	21.4	26.3
56–65	56	54.4	80.6
>65	20	19.4	100.0
Total	103	100.0	–

Regarding the risk factors, more than half of the sample declared to be healthy with a matching lifestyle. Thus, 64.1% (n = 66) did not declare any of the risk factors. Only 19.4% (n = 20) were diabetic. Twelve participants (11.7%) were smokers. A very small percentage of the participants (4.9%) had bruxism (Table 2).

As to the reasons for tooth loss, the most common answers were periodontitis (40.8%) and caries + periodontitis (41.7%). Only 5 persons (4.9%) reported having lost teeth due to trauma and 13 others (12.6%) referred to caries as the main cause.

Of the total sample, 58.3% (n = 60) rehabilitated the maxilla and 41.7% (n = 43) rehabilitated the mandible.

Table 2. Distribution by risk factors

Risk factor	Frequency *n*	Valid percentage [%]	Aggregate percentage [%]
Bruxism	5	4.9	4.9
Smoking habit	12	11.7	16.6
Diabetes	20	19.4	35.9
None	66	64.1	100.0
Total	103	100.0	–

The dentists responsible for maxillary rehabilitation were questioned about the possible interference of a bone deformity in the process. The vast majority of the patients did not present any bone deformities, corresponding to 91.3% (n = 94) of the sample.

Oral rehabilitation data

The dentists were asked about some aspects of the rehabilitation they had performed. The vast majority did not find it necessary to perform bone grafts prior to implant placement.

Accomplishment

The dentists were asked about the success of rehabilitation. Approximately 70.9% (n = 73) reported successful procedures and 29.1% (n = 30) admitted treatment failure.

For those who were successful, the questionnaire ended here.

Failure

The authors of the present study wished to learn what caused failed cases.

Four out of the 30 previously presented unsuccessful cases did not include information about what had caused the failure. Therefore, they were excluded from the analysis of this item.

The failure with the highest incidence, with 46.2% (n = 12) of the answers, was the fracture of the prosthetic part. The second most recurrent cause, but with a significantly lower percentage, was peri-implantitis, comprising 23.1% (n = 6) of the answers, followed by secondary stability (15.4%) and unscrewing (11.5%). Primary stability failed in only 1 (3.8%) of the studied cases.

We also wanted to know the length of time between rehabilitation and failure. The most frequent answer (88.5%) indicated that failure occurred 6 months after rehabilitation. In only 3 cases of rehabilitation, failure occurred in a period of time shorter than or equal to 6 months.

In 91 out of the 103 study cases, no implants were lost. However, we wanted to know how many failed. Among 12 rehabilitation cases in which implants failed, there were 2 reported cases of 3 lost implants (16.7%). In the remaining cases there was 1 failed implant (83.3%).

Variable cross-checking

To verify whether there were any significant relationships between the variables, we used the χ^2 test of independence.

In this test, the null hypothesis (H0) assumes that there is no association between the variables – they are independent; therefore, this hypothesis must be rejected.

It is concluded that the variables may be associated if the resulting p-value is under 5%. However, the use of this test depends on the validation of 2 assumptions – that a maximum of 20% of the cross-table cells have the expected values lower than 5 and that the expected minimum value is greater than 1.

Relationship between maxillary and mandibular rehabilitation and success

Of the 60 persons with implants in the upper jaw, 40 (66.7%) were successful. That success percentage rose to 76.7% for mandibular rehabilitation.

The resulting p-value was 0.267 (>0.05). Therefore, the type of rehabilitation and the rate of success were not significantly related issues (Table 3).

Table 3. Distribution according to the relationship between maxillary and mandibular rehabilitation and success

Jaw	Success				Total	
	yes		no			
	n (%)	success rate [%]	*n* (%)	success rate [%]	*n* (%)	success rate [%]
Maxilla	40 (66.7)	54.8	20 (33.3)	66.7	60 (100.0)	58.3
Mandible	33 (76.7)	45.2	10 (23.3)	33.3	43 (100.0)	41.7
Total	73 (70.9)	100.0	30 (29.1)	100.0	103 (100.0)	100.0

Relationship between the risk factors and success

In this case, the χ^2 test could not be applied; thus, bruxism and smoking habits were grouped. The results of the new data crossing are presented below (Table 4).

Of the 17 smokers with bruxism, 13 (76.5%) had successful rehabilitation and 4 (23.5%) did not.

Of the 20 diabetic persons, 18 (90%) had successful rehabilitation.

Of the 66 persons with no risk factors, 42 (63.6%) were successfully rehabilitated and 24 (36.4%) were not.

The resulting p-value was 0.065 (>0.05). Therefore, the risk factors and the rate of success were not significantly related (Table 5).

Table 4. Distribution of the correlation between the risk factors and the success rate

Risk factor	Success				Total	
	yes		no			
	n (%)	success rate [%]	*n* (%)	success rate [%]	*n* (%)	success rate [%]
Bruxism	3 (60.0)	4.1	2 (40.0)	6.7	5 (100.0)	4.9
Smoking habit	10 (83.3)	13.7	2 (16.7)	6.7	12 (100.0)	11.7
Diabetes	18 (90.0)	24.7	2 (10.0)	6.7	20 (100.0)	19.4
None	42 (63.6)	57.5	24 (36.4)	80.0	66 (100.0)	64.1
Total	73 (70.9)	100.0	30 (29.1)	100.0	103 (100.0)	100.0

Table 5. Distribution according to the relationship between the risk factors and rehabilitation success with bruxism and smoking groups

Risk factor	Success				Total	
	yes		no			
	n (%)	success rate [%]	*n* (%)	success rate [%]	*n* (%)	success rate [%]
Bruxism/ Smoking habit	13 (76.5)	17.8	4 (23.5)	13.3	17 (100.0)	16.5
Diabetes	18 (90.0)	24.7	2 (10.0)	6.7	20 (100.0)	19.4
None	42 (63.6)	57.5	24 (36.4)	80.0	66 (100.0)	64.1
Total	73 (70.9)	100.0	30 (29.1)	100.0	103 (100.0)	100.0

Relationship between the technique used and the success rate

In the All-on-4 technique, of the 68 cases, 48 were successful and 20 were not. In the All-on-5 technique, 5 (62.5%) of the 8 cases were successful and 3 (37.5%) were not. Finally, in the All-on-6 technique, 74.1% of cases were successful.

Among the successful cases, the most commonly used technique was All-on-4 (65.8%), followed by All-on-6 (27.4%), and finally All-on-5 (6.8%).

The resulting *p*-value was 0.815 (>0.05). Therefore, the technique used and the success rate were not significantly related (Table 6).

Implant data

The applied techniques were classified according to the number of implants used for maxillary and mandibular rehabilitation. A total of 66.0% (n = 68) implants underwent the All-on-4 procedure, while 26.2% (n = 27) underwent the All-on-6 procedure and a minority – 7.8% (n = 8) – utilized the All-on-5 procedure.

Table 6. Distribution of the correlation between the technique used and the success rate

Technique	Success				Total	
	yes		no			
	n (%)	success rate [%]	*n* (%)	success rate [%]	*n* (%)	success rate [%]
All-on-4	48 (70.6)	65.8	20 (29.4)	66.7	68 (100.0)	66.0
All-on-5	5 (62.5)	6.8	3 (37.5)	10.0	8 (100.0)	7.8
All-on-6	20 (74.1)	27.4	7 (25.9)	23.3	27 (100.0)	26.2
Total	73 (70.9)	100.0	30 (29.1)	100.0	103 (100.0)	100.0

Regarding the brand of the implants used, in 46.6% of cases (n = 48), Nobel was chosen. Mis and Strauman were chosen by a minority of the inquired dentists – only 8.7% (n = 9). MegaGen was the choice of 26 dentists (25.2%) (Table 7).

Table 7. Distribution according to the implant brand

Brand	Frequency *n*	Valid percentage [%]	Aggregate percentage [%]
Nobel	48	46.6	46.6
Mis	7	6.8	53.4
Strauman	2	1.9	55.3
MegaGen	26	25.2	80.6
Other	20	19.4	100.0
Total	103	100.0	–

The length and diameter of the implants used also varied.

Most of the surveyed dentists – 83.5% (n = 86) – opted for implants of a length between 10 and 13 mm. The options 'less than 10 mm' – 1.9% (n = 2) – and 'more than 13 mm' – 14.6% (n = 15) – were not frequently chosen.

Most dentists – 77.7% (n = 80) – used implants whose diameter varied between 3 and 4 mm. Only 22.3% (n = 23) opted for diameters greater than 4 mm.

Osteointegration

Then, the binomial test was performed to assess the proportion of osteointegration. The null hypothesis to be tested was that the non-osteointegration ratio was 3%, i.e., the osteointegration rate was 97%. The test yielded a *p*-value of 0.351 (>0.05). At a significance level of 5%, it could not be concluded that non-osteointegration was greater than 3% and osteointegration was not less than 97%.

Differences in osteointegration between the jaws

To verify whether there were significant differences in osteointegration between the jaws, the *t* test was used. This test led to a *p*-value of 0.443 (>0.05). Therefore, despite the differences observed in the previous description, these differences were not significant. That is, there were no significant differences in osteointegration between the 2 jaws. The χ^2 test led to a *p*-value of 0.442 (>0.05), so the variables were not related, and the jaw and osteointegration were independent of one another (Table 8).

Table 8. Distribution of upper and lower jaw osteointegration (total number of implants *N* = 474)

Osteointegration	Upper jaw *n* (%)	Lower jaw *n* (%)
Yes	273 (97.2)	185 (95.9)
No	8 (2.8)	8 (4.1)
Total	281 (100.0)	193 (100.0)

Discussion

The present study comprised a sample of 474 implants placed in 103 patients. It can be considered a very satisfactory sample size, since the work in question can be categorized as a cross-sectional, observational study, and similar studies can be found in the literature that have an identical or lower sample size in comparison with the present one. The traditional method of distribution of the questionnaire (filling in paper) proved to be ideal for obtaining a greater number of responses. The questionnaires were completed by the author in the presence of patients, providing greater answer reliability. The choice of the region for the application of the questionnaire (Porto, Portugal) was conditioned by the researcher's easier access and communication to the potential participants in this particular area.

Due to the use of the traditional method for disseminating the questionnaire, data processing and the statistical analysis required a greater amount of time on the part of the researcher, since it was necessary to manually enter all the responses/results into the computer program. This manual process of filling in/inserting data can lead to an error associated with manual transposition. The main objective of the present investigation was to evaluate the success rate of immediate-load rehabilitation in edentulous jaws. This assessment was carried out based on the patients' responses to the questionnaire and the review of clinical records, so the existence of a response bias should be considered. This may be particularly evident in questions regarding the reason(s) for tooth loss and the presence of risk factors, where participants may have been influenced to respond according to what is most accepted or considered most correct. It is known that to use an immediate loading protocol, certain patient selection criteria must be followed.[18] It was found that the presented sample was mostly healthy; however, we had 19.4% diabetics, 11.4% smokers and 4.9% bruxism patients. When these variables were correlated, it was found that the risk factors and the occurrence of complications were not significantly related. The primary reason for tooth loss was periodontitis (82.5%), with the remainder divided between caries and trauma. More maxillae than mandible jaws were rehabilitated (58.3% and 41.7%, respectively). The vast majority (91.3%) did not present bone defects and only 12.6% required grafts. The most commonly used technique was All-on-4, which can be explained by the lower number of implants the technique requires; therefore, it becomes more economical and easier to sanitize the hybrid denture. The All-on-6 technique was the second choice with 26.2%, and finally the All-on-5 technique with 7.8%. We found that the technique used and rehabilitation success were not statistically significantly related, emphasizing what was mentioned in 2005 by Balshi et al., who claimed to find no relationship between the number of implants and success.[19] However, Szmukler-Moncler et al. claimed that 6 implants was the appropriate number to achieve a predictable result.[15] For Maló et al.,[10,20] the All-on-4 technique provided very predictable and successful results.[15] The implants were placed in both jaws. Since more maxillae than mandibles were rehabilitated, depending on the number of implants used in each technique, it was found that more implants were placed in the upper jaw. The implant length chosen in this study was mostly between 10 and 13 mm (83.5%). These values are within what is considered an implant length (≥10 mm) adequate to predictably perform total rehabilitation via an immediate load. However, Balshi et al. say they prefer to use longer implants, whenever possible, stating that the lengths between 13 and 15 mm are frequently used.[19,21] In situations of low bone height, the inclination of implants may be a solution for posterior regions.[19] Regarding the diameter, Balshi et al. state that 4-millimeter-wide implants are generally the first choice.[21] Accordingly, in this study, the diameter oscillated between 3 and 4 mm, making up 77.7% of the implants placed. Only 22.3% of the implants placed had a diameter greater than 4 mm. Maló et al.[20] and Javed et al.[14] reported higher failure rates in implants of larger diameters, which was associated with implantation in bone types III and IV.[21]

The existence of some complications was verified in this study. The most frequent one was the fracture of the prosthesis (46.2%), followed by peri-implantitis (23.1%), and finally unscrewing (11.5%). Most cases occurred 6 months after surgery (88.5%). Only 11.5% of cases occurred in the first 6 months after surgery.

We found that the type of jaw and the occurrence of complications were not statistically significantly related.

Both biological and prosthetic complications are rare in studies of immediate loading with complete-arch prostheses. Pain and edema are common.[19]

According to Gallucci et al.,[22] the survival rate of the temporary prostheses used in their study, in immediate loading, was 100%.[23] Balshi et al. reported a rate of 99.0%.[19] On the other hand, Jaffin et al. replaced a fixed temporary prosthesis with a removable prosthesis during osteointegration due to the loss of several implants.[24]

In this study, of the 474 implants placed, 16 did not osteointegrate, with an osteointegration rate of 97%. We found that there were no significant differences in osteointegration between the 2 jaws, and that the technique used and osteointegration were independent.

In 2014, Balshi et al. proved a higher success rate of the All-on-4 technique in edentulous jaws as compared to dentulous jaws.[21] However, in 2011, Maló et al. studied the viability of the All-on-4 technique in a medium and long term in edentulous jaws, obtaining an implant survival rate of 98% in a sample of 968 immediate-load implants.[20] They concluded, therefore, that it was a viable technique that worked as a good medium- and long-term treatment alternative.[20] However, in 2015, Lopes et al., in a study with a sample of 92 implants placed according to the All-on-4 concept, obtained survival rates of implants and prostheses of 96.6% and 100%, respectively, at 5 years of follow-up.[25] They concluded, therefore, that the technique was safe and predictable.[25] According to Gallucci et al.,[22] 2 articles published by Grunder[26] and Cooper et al.[27] reported a survival rate of 97 implants placed in 15 patients, which ranged from 97.7% to 100%. One of the articles reported non-prosthetic failure, with the prosthesis survival rate being 100%.[22]

In a prospective study, Balshi et al. suggested that an immediate loading protocol was suitable for all types of patients who needed oral rehabilitation.[19] Tarnow et al. immediately loaded 36 implants and obtained a 97.4% survival rate.[28]

Jaffin et al. reported a 93% osteointegration rate in 236 implants placed to rehabilitate 34 patients.[24] The main causes of failure were identified as an inadequate prosthesis and the chewing of hard foods, which resulted in the micromotions of dental implants, interferring with the process of osteointegration.[24]

Conclusions

Within the limitations of this study and considering the proposed objectives, we can conclude the following:

The rate of osteointegration of the 474 implants placed with an immediate loading protocol was 97%. This rate is in agreement with the rate described in the literature. This outcome indicates that this is a predictable alternative to a conventional cargo.

It was found that the type of jaw and the occurrence of complications were not related. Therefore, the rehabilitation of the mandible or the maxilla will not necessarily bring associated complications.

The risk factors and the occurrence of complications were also unrelated. In other words, it was possible to successfully rehabilitate patients with risk factors, just as the healthy ones.

The rate of osteointegration did not vary depending on the rehabilitated jaw. These variables were independent.

The technique used and osteointegration proved to be independent as well.

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