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CLINICAL RESEARCH:

Implant Survival Rate and Prosthetic Complications of Full-arch Implant-supported Fixed Prostheses In Edentulous Upper Jaws: A Cohort Study

Tasa de supervivencia de los implantes y complicaciones protésicas de las prótesis fijas soportadas por implantes de arcada completa en maxilares superiores edéntulos: un estudio de cohorte

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ABSTRACT: Full-arch implant-supported fixed dental prostheses, an implant-supported prosthesis, which the patient must carefully manage in home oral hygiene procedures, is the fixed alternative to a mucosal-supported or implant-anchored prosthesis. Clinically, the execution of this rehabilitation requires four implants for the lower jaw and six implants for the upper jaw. The aim of the present study is to verify the survival-rate of implants for implant-fixed prostheses in the edentulous upper jaw. This retrospective study was carried out on patients who received an upper full-arch fixed prostheses on six implants for rehabilitation. A total of 36 patients were included and evaluated from a clinical and radiographical point of view. The follow-up period in which the data were collected on the upper full-arch is between 60 and 84 months. A total of 232 implants were inserted and monitored in this period. Clinical and radiographic evaluations were carried out on all 232 implants, with constant re-evaluation. The total implant survival

rate is 93.1%, a value which is similar to previous studies already published on the topic. There were few prosthetic complications, mainly the fracture of anterior prosthetic teeth. Most of these full-arch, which as antagonist had another previously made full-arch implant-supported fixed dental prostheses or overdenture on four or overdenture on two implants, achieves good results in this study at 84 months.

KEYWORDS: Full-arch; Implant-supported; Fixed dental prostheses; Cement-retained; Cr-Co; Resin; Composite.

RESUMEN: Las prótesis dentales fijas implantosoportadas de arcada completa, una prótesis implantosoportada, que el paciente debe manejar cuidadosamente en los procedimientos de higiene bucal domiciliaria, es la alternativa fija a una prótesis soportada por mucosas o anclada a implantes. Clínicamente, la ejecución de esta rehabilitación requiere cuatro implantes para el maxilar inferior y seis implantes para el maxilar superior. El objetivo del presente estudio es verificar la tasa de supervivencia de los implantes para prótesis fijadas sobre implantes en el maxilar superior edéntulo. Este estudio retrospectivo se llevó a cabo en pacientes que recibieron prótesis fijas de arcada completa superior sobre seis implantes para rehabilitación. Se incluyeron y evaluaron desde el punto de vista clínico y radiográfico un total de 36 pacientes. El período de seguimiento en el que se recogieron los datos de la arcada completa superior es de entre 60 y 84 meses. En este período se insertaron y controlaron un total de 232 implantes. Se llevaron a cabo evaluaciones clínicas y radiográficas de los 232 implantes, con una reevaluación constante. La tasa de supervivencia total de los implantes es del 93,1%, valor similar a estudios previos ya publicados sobre el tema. Hubo pocas complicaciones protésicas, principalmente la fractura de los dientes protésicos anteriores. La mayoría de estos pacientes de arcada completa, que como antagonistas habían confeccionado previamente otras prótesis dentales fijas implantosoportadas de arcada completa o sobredentaduras de cuatro o sobredentaduras de dos implantes, logran buenos resultados en este estudio a los 84 meses.

PALABRAS CLAVE: Prótesis dentales fijas; Implantosoportadas; De arcada completa; Cementadas; Cr-Co; Resina; Composite.

INTRODUCTION

Edentulism or a terminal dentition is still a very represented social problem and public health challenge today, although the incidence of this condition in the population has been decreasing dramatically in recent years (1).

In this context, the use of these rehabilitative procedures makes it possible to restore the lost functions and aesthetics either because edentulism or incongruous total prostheses are now present, or because of the presence of a terminal dentition often with a high degree of mobility (2,3). To date, the classic therapy for total edentulism, recommended for more than 20 years by Feine *et al.*, is a complete upper denture and a lower overdenture with at least two implants (4).

After the delivery of implant-supported prostheses, patients reported a significant improvement in their quality of life (5). In the last ten years, the systematic reviews of the biological aspects and technical complications of fixed

implants restorations in edentulous jaws and implant and prosthodontics survival rate reported an implant survival rate from 96.7% to 99.2% at 10 years (5-8).

Although there are different types of complete prosthesis retained on implants, the cases selected in this study include only and exclusively prostheses cement-retained on implants, with cements whose respect for the peri-implant tissues has been investigated in recent years: zinc oxide non-eugenol Temp Bond (Kerr Corporation, Orange, California, USA) (8-10).

No immediate fixed prosthesis, although with the appropriate materials there was both a possibility that the indication was loaded immediately, and all surgeries were in two stages (11).

The position of the implants had been planned according to the position of the teeth under load, with the distal implant at most in the upper first/second molar area, never more distal. The cemented solution, with a depth of the cementation groove equal to zero, for all the abutments the finish-line was juxta-gingival, and in the aesthetic zone, this was masked by the "pink" flange of the prosthesis.

The quality of the tissue around the implants is absolutely fundamental, both in terms of thickness and volume, and for the creation of a truly stable and reliable mucosal seal over time. it is now proven that this seal guarantees the aesthetic and functional result of the system over time (12-16).

If the thickness or volume of the peri-implant soft tissue was not sufficient, or a surgical augmentation of the peri-implant soft tissue was performed at the first or second surgical stage (16,17).

The choice of this solution made it possible to completely avoid bone regeneration techniques, inserting all the implants in native bone, where the extractions had been performed at least 4 months before the implant insertion surgery.

The choice of the different prosthetic possibilities is fundamentally represented by the 3D positioning of the implants and their mutual inclination (18).

All the rehabilitations examined have in contrast an implant-supported fixed restoration or an overdenture on 4 implants or an overdenture on two implants. These upper jaw full-arch are all or an evolutions of a previously made complete denture, to reduce the intraoral dimensions of the rehabilitation, especially due to important gagging reflex or patient request, or identified as first choice in the treatment plan for functional and aesthetic reasons. The aim of this study was to evaluate the survival rate (post-loading implant loss) and prosthetic complications for full-arches on six implants in the edentulous upper jaw.

MATERIALS AND METHODS

This retrospective cohort study was carried out on patients who received for rehabilitation an upper jaw full-arch retained on six implants.

ETHICAL APPROVAL

This study was approved by the Ethics Committee of the Campus Bio-Medico University of Rome.

PATIENTS SELECTION AND INCLUSION/EXCLUSION CRITERIA

All patients had lower jaw full arch rehabilitation, lower jaw overdentures retained on two or four implants or fixed dentures for at least 2 years. All the implants inserted, therefore, are inserted in edentulous jaws for years. A total of 232 implants Tapered Internal Laser-Lok® (BioHo-

rizons, Birmingham, AL, USA) were inserted and monitored over a period of 48-72 months with clinical and radiographic tests. Implants of different diameters and lengths were used, all of the same series.

IMPLANTS PLACEMENT

In this study, computer-assisted image analysis was used to evaluate mesial and distal bone levels on periapical intraoral radiography. For the radiograph procedure, an individualized acrylic resin device was fixed, as much as possible, parallel to the fix under study, and a radiograph holder was constructed for each patient.

Patients scheduled for surgery were prescribed systemic antibiotic: amoxicillin/clavulanic acid (Augmentin, GlaxoSmithkline, London, England), 1 g, twice a day for 6 days, and a chlorhexidine digluconate solution 0.12% (Dentosan 0, 12%, Johnson & Johnson, USA) rinse (twice daily for 1 min).

After local anesthesia by infiltration using articaine/epinephrine (Ecocain 20 mg/mL, Molteni Dental, Italy), surgical access with a mid-crestal incision in the center of the edentulous ridge was performed, elevating a full-thickness flap.

Following implant placement, the full thickness flap was sutured without tension using 4.0 or 5.0 monofilament sutures, which were left in place for 10 days. As the first part of a two-stage technique, the implant was submerged, and the second surgical stage was carried out after 4 months.

Once the healing screw was inserted, suturing was not necessary in most cases, and where a larger flap was needed, mainly for soft tissue management, the flap was sutured and sutures were left in place for 10 days.

PROSTHESIS DELIVERY

At this point, after an open-tray impression on a custom tray, the heights of the mucous cones were measured for the choice of the height of the abutments individual abutments, which will then be milled by the technician while maintaining a large contact surface with the internal part of the prosthetic structure. A full-arch with a laser-sintered Cr-Co framework, composite teeth and resin flanges was produced with a full analog workflow. The prosthesis was stabilized on the implants using original abutments milled by the technician to make them parallel, and cemented with temporary cement zinc oxide non-eugenol Temp Bond (Kerr Corporation, Orange, California, USA), to make it possible to remove it when required. Delivery of the final prosthetic device was performed approximately 6 months after implant placement.

PATIENTS' EVALUATION

The follow-up period for patients after the delivery of the upper full-arch is between 60 and 84 months. Patients were recalled after the first month following the setting and then every 4 months in the first year. The follow-up visit for the following years was variable, but, for all patients, follow-up visits occurred at least twice a year. The implant survival criteria followed the Pisa consensus statement of the ICOI Conference 2007. The implant is considered 'survived' if its superstructures function normally when clinically evaluated.

The implant was considered 'failed' if at least one of the following signs were present.

- Pain on palpation, percussion or function of the implant.
- Any mobility (horizontal and/or vertical) of the implant.

- Purulent exudate.
- Uncontrolled progressive bone loss.
- Radiographic bone loss > ½ length of implant.
- Removed, no longer in mouth.

STATISTIC ANALISYS

The dependent variable in the analysis was implant failure. Descriptive statistics including frequencies, means and standards deviations were calculated for all examined variables. Continuous variables were compared with the t-test, while categorical variables were expressed as proportions and compared with fisher's exact test. All tests of significance were evaluated at the 0.05 error level with a statistical software program (SPSS v.19.0, IBM, Armonk, NY, USA).

RESULTS

A total of 42 patients (22 males and 20 females) were included in this study and initially evaluated clinically and radiographically. A number of 6 patients were excluded as they had not followed the agreed recall schedule. After this selection, the results of 36 patients (19 males and 17 females) were processed. The follow-up period for patients after delivery of the upper overdenture was between 60 and 84 months. During the observational period, 16 implants failed (Table 1).

The implant diameters used were 3.0mm, 3.8mm, 4.2mm, and 4.6mm. The implant lengths used were 7.5mm, 9mm, 10.5mm, 12mm, and 15mm. Among the failed implants, with a majority in the posterior sectors of the upper jaw, the 4.6mm in diameter are the implants that have failed in the majority of cases of overall failure.

The male/female distribution is almost equal, with differences that are not statistically significant.

When indicated anterior/posterior, in this type of rehabilitation on six implants, the asymmetric positioning was considered, up to and including the first upper premolar they were part of the anterior group (aesthetic area), after the first premolar (excluded) they were part of the posterior sectors.

Considering the 232 implants evaluated, the totall implant survival rate is 93.1%, similar to other previously reported datas.

Compared to a study of a similar population and the same implants by the authors of the present study, the implant survival rates are moderately higher (3).

For each type of implant, the survival rate and the radiographic stability characteristics of the implant-supporting bone were analysed.

Table 2 shows the implant survival rate and other parameters studied on surviving implants.

The percentages of peri-implant bone resorption and remodeling are in line with what is considered physiological and keep the survival percentage high over time (12,13).

Considering the use of a temporary cement for the stabilization of the full-arch at the level of the six abutments, of which no breakage was found, 3 decementations occurred in these 48-72 months of observation, thus guaranteeing a reliable and clinically valid.

Compared to supported, but not fixed, implant prostheses, the incidence of fracture of veneers or teeth is considerably higher, considering the extent of the forces that are not attenuated by the prosthetic material due to the presence of the metal framework (11). These stresses are then distributed drastically at the level of the coatings, and manifest the detachment of these from the metal, or the chipping of the composite teeth, as indicated in Table 3.

Table 1. Failed fixtures (characteristics and positions). Each implant was removed with pain, bone loss, exudate. * Months before implant failure occurrence. ** M = male/F = female.

		Posterior	Anterior	Months *	Patient Age/Sex **
1	3.0 × 10.5	X		9	67 (M)
2	3.0 × 10.5	X		12	72 (F)
3	3.0 × 12		X	12	78 (M)
4	3.8 × 12		X	24	72 (F)
5	3.8 × 12		X	0	54 (M)
6	3.8 × 10.5	X		12	60 (M)
7	3.8 × 10.5		X	36	62 (F)
8	4.2 × 12	X		12	72 (F)
9	4.2 × 12	X		0	54 (M)
10	4.2 x 12		X	12	60 (M)
11	4.6 x 7.5	X		36	55 (F)
12	4.6 × 7.5	X		24	70 (F)
13	4.6 × 9	X		0	56 (M)
14	4.6 x 9	X		9	54 (F)
15	4.6 x 12	X		24	66 (M)
16	4.6 × 12	X		36	58 (M)

Table 2. Implant survival rate and Marginal Bone Loss (MBL) at 60 months.

					Bone Loss	P-Value
		N. Implants	Failed	Survival Rate	M	D
Implant diameter	3.0 mm	11	3	72.7%	1.2 ± 1.1 mm	1.5 ± 1.0 mm (0,06)
	3.8 mm	45	4	91.1%	1.2 ± 1.0 mm	1.4 ± 1.1 mm (0.14)
	4.2 mm	90	3	96.7%	1.3 ± 0.8 mm	1.2 ± 0.7 mm (0,31)
	4.6 mm	86	6	93%	1.4 ± 0.8 mm	1.5 ± 1.1 mm (0,23)
Location	Ant	140	5	96.4%	1.1 ± 1.0 mm	1.3 ± 0.6 mm (0,07)
	Post	92	11	88%	1.3 ± 1.1 mm	1.7 ± 0.9 mm (0,03)

* Statistical significance with p-value ≤ 0.05 shown in bold.

Table 3. Prosthetic complications in full-arches during the 84 months of observation. Right rear areas (Post dx), Left rear (Post sx), Right front (Ant dx), Left front (Ant sx). * more than 1 mm per year.

	Post dx	Ant dx	Ant sx	Post sx	TOT
Abutments Damage	0	0	0	0	0
Abutments Screw loosening	3	2	2	4	11
Premature Teeth wear *	14	3	2	15	34
		16 (1.2)	13 (2.2)		
Prosthetic Teeth Fractures (n.)	2	14 (1.1)	13 (2.1)	3	88
		12 (1.3)	15 (2.3)		
Prosthesis Flanges Damages	0	0	0	0	0

DISCUSSION

The present study examined the survival rate of the implants and the prosthetic complications of full-arch (on six implants) and its prosthetics components, with a fixed-rehabilitation or an overdenture as antagonist. With the implant survival criteria used, the results were comparable to the data already published in literature, and this solution guaranteed a good level of success.

Compared to a study recently published by the same Authors, using the same implants, with overdentures as the final device (always for the upper arch), implants with a smaller diameter, although positioned in the distal areas of the jaw, do not show the same degree of failure compared to when held free, not bound to a single structure, but with a OT Equator retention devices (Rhein'83, Bologna, Italy) (3,19).

Considering the overall results of the study, the loss of implants after loading, in the 48/72 months of observation, is in any case lower than the percentage obtained by the same authors using the same implants, but with a removable prosthetic device (3). This result can be associated with the effectiveness of passive solidification of the implants using a rigid metal bar, which allows for a more effective distribution of forces. Another possible explanation, although the possibility of managing the patient's hygiene is more complex, the presence of six implants that support the rehabilitation ensures greater stability of the result compared to 4 implants and one overdenture (3,20,21).

The presence of six implants also guarantees that in the event of an implant failure it is possible, often without modifications, to keep the full-arch in position, although limited in the possibility of further modifications (22).

Large-diameter implants were not found to be more effective; indeed, among those with larger diameters, the shorter the length, the shorter the survival, as indicated in previous studies (23,24). There is no evidence that from the point of view of implant inclination, compensated by an angled abutment, there may be significant differences in terms of implant duration over time (20).

Among the failed implants, with a majority in the posterior sectors of the upper jaw, the 4.6mm in diameter are the implants that have failed in the majority of cases of overall failure.

The male/female distribution is almost equal, with differences that are not statistically significant.

Explaining this detail is certainly not easy, and although there are differences between the behavior of implants of different diameters, the fact of having a Cr-Co framework to consolidate the implants makes it difficult to separate or exclude some variables from others. Certainly, the greater the implant diameter in an edentulous crest, the smaller the bone volumes around it. As this area is subjected to constant masticatory loads, smaller volumes of bone are more easily subject to resorption phenomena, compromising overall implant rehabilitation (25,26).

The difference that was found on the same implants, but with a different anchoring technique on the implant success, although minimal, is attributable to the splinting of the implants between them (3,27-30).

Having used a temporary cement such as zinc oxide non-eugenol Temp Bond (Kerr Corporation, Orange, California, USA), only caused 3 decementations of the full-arches cemented on 6 abutments, validating this possibility in case it was necessary to resort to cement-retained rehabilitations of this type.

The implant success values, considering the selected prosthetic solution, represent an excellent starting point for improving a technique that is extremely simple and less expensive than others today, especially by applying it to a large part of the edentulous population. The prosthetic materials of which the definitive prosthesis is made are an internal laser-sintered bar in Cr-Co and a covering in resinous materials, composites for the teeth and acrylic resin for the flanges. This solution allows simple modifications, reduced costs and ease of reoperation, also considering a weak cementation that allows the device to be removed if necessary.

CONCLUSIONS

The survival rate of the implants included in this study was 93.1% for these upper jaw full-arch. These excellent success rates in this study after at most 84 months were achieved with different types of complete prostheses in occlusion, both mucosa-supported, retained and fixed on implant. The number of failed implants is similar to the data reported in the literature, with a predisposition to the loss of posterior implants compared to anterior ones. As prosthetic complications, the only noteworthy one in terms of frequency was the fracture of the upper frontal prosthetic teeth.

Within the limitations of this study, it is possible to define this rehabilitation strategy as valid, allowing a totally edentulous patient to have a better quality of life and good long-term rehabilitation success.

AUTHOR CONTRIBUTION STATEMENT

Conceptualization: R.R. and V.B.
Methodology: A.Z. and M.S.
Software: F.P.
Validation: R.R., D.D.N. and L.T.
Formal analysis: E.X.
Investigation: R.R and M.D.
Resources: D.D.N and L.T.
Data curation: M.D. and M.S.
Writing-original draft preparation: R.R. and A.Z.
Writing-review and editing: E.X. and D.D.N.
Visualization: D.D.N.
Supervision: L.T.
Project administration: L.T.

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