Original Research
Prosthesis

Prosthetic complications and quality of life among wearers of mandibular overdenture with the Facility-Equator system

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Abstract: This longitudinal study aimed to assess the performance of the Facility-Equator system as mandibular overdenture (MO) retainers from a prosthetic perspective during 2 years of loading and to investigate the oral health-related quality of life (OHRQoL) and whether prosthetic events can affect the OHRQoL. Twenty-four patients (68.1 ± 7.51 years) reported their OHRQoL through the Geriatric Oral Health Assessment Index (GOHAI) and Oral Health Impact Profile (OHIP-EDENT) questionnaires before MO loading and after 1 and 2 years of usage. Prosthetic occurrences were recorded during this period. Data were analyzed using the Wilcoxon test, Mann-Whitney test, and Spearman correlation coefficients. Of the 127 prosthetic events that occurred in the first year, the most frequent events were prosthesis adjustments (16.5%), dislodgement of the Equator attachment (14.17%), and O-ring replacement (11.8%). Eighty-seven prosthetic events were recorded in the second year, the most frequent events being prosthesis adjustments (27.6%), O-ring replacement (20.7%), and recapturing the female matrix (11.5%). All domains of the GOHAI and OHIP-EDENT questionnaires exhibited a significant difference ($p < 0.05$) between the baseline and 1- and 2-year evaluations, except in the Social Disability and Psychological Discomfort domains ($p > 0.05$) of OHIP-EDENT after 1 year. Complications related to prosthetic maintenance, such as fracturing of the prosthesis, Equator dislodgement, prosthesis rebasing, and new overdenture confection, affect the OHRQoL ($p < 0.05$), primarily the Physical Pain and Discomfort domains, especially in the first year of MO loading.

Keywords: Dental Implants; Dentures; Prosthodontics; Quality of Life.

Introduction

Mandibular overdenture (MO) retention systems have different effects on the biomechanical and clinical performance of the prosthesis; however, it is still unclear which system results in better function and mechanical performance and provides greater comfort and quality of life to the patient.[1] Several types of attachment systems available on the market have been used to promote MO retention, providing better functional

stabilization. These attachments are classified into two major categories: splinted attachments, such as the bar type, and non-splinted ones, such as the ball-type, magnet, and stud attachments.[2] Within the non-splinted systems category, the Facility-Equator system is relatively new to the market and has been commercially available since 2013. The system is an attachment connected to a narrow diameter morse taper implant (NDI - Ø 2.9 × 10 mm) with a screwless morse taper connection based on pure frictional retention and a stud type attachment installed using a hammer when this system is used as an overdenture retainer.[3] This system is intended for use in mandibles with limited bone availability. Several aspects of Equator attachments used as MO retainers have been studied, such as their relationship with quality of life, masticatory function,[4,5] clinical peri-implant, and biological aspects,[6,7] and performance according to loading protocols.[8] However, little is currently known about the profile of complications and prosthetic events that may be related to the Facility-Equator system, and these data are essential for patients and clinicians as they permit to develop a more holistic prognostic measure that helps in the selection of implant systems.

Studies have shown that prosthodontic maintenance events and prosthodontic complications during MO treatment may vary according to the attachment system used, while the patient's satisfaction level and quality of life and the survival rates of the implants are not affected by the selected attachment.[9-11] A recent systematic review showed that mastication, bone loss, and patient satisfaction were not influenced by the MO attachment type (bar and clip or ball and O-ring).[1] However, other studies indicated that the oral health-related quality of life (OHRQoL) after rehabilitation may be associated with the type of retainer used.[12,13] For instance, Matthys et al.[14] reported more frequent maintenance interventions in stud attachments (locator) in comparison with the ball system, which led to higher maintenance costs and negatively influenced the OHRQoL outcomes during the five-year follow-up.[14] In addition, Mahanna et al.[13] observed that stud attachments were more advantageous in terms of comfort and self-consciousness, promoting the feeling that the prosthesis is a part of the patient, whereas bar and telescopic attachments were associated with higher satisfaction during chewing of soft and hard foods, and telescopic and stud attachments resulted in more satisfaction during oral hygiene.[13]

The effect of implant prostheses-related complications on patient satisfaction and OHRQoL is not frequently investigated, and as a result, it is not well understood. Moreover, there are no evidence-based guidelines as to what level of maintenance care should be anticipated or what would constitute excessive aftercare.[15] Meanwhile, patients using MO who experienced prosthesis-related complications and those who were concerned about potential complications reported lower OHRQoL scores compared to those without complications.[16] However, MO significantly improved patient satisfaction, reduced patient complaints, and improved patient-reported outcomes achieved when they remained stable for at least 5 years; most technical complications and maintenance events were clustered in the first year and were significantly correlated with overall patient satisfaction after 1 year.[15]

However, despite all the benefits that MO bring to patients' lives, the prosthodontic maintenance involved in MO treatment has a significant impact on the clinical and laboratory expenses of this treatment and can influence patient satisfaction with the treatment over time. Therefore, it is essential to prospect the maintenance needs in order to ensure treatment success and avoid unexpected events that affect the relationship between the dental surgeon and the patient.[14,17,18] Due to the large variety of available systems, several studies present comparisons between the attachment systems; however, there is limited information regarding the prosthodontic maintenance that can occur when these systems are used as MO retainers in atrophic mandibles, especially concerning the Facility-Equator system (Neodent, Curitiba, Brazil). Currently, little is known about its long-term behavior, especially regarding prosthetic occurrences.

Thus, the aim of the present study was to evaluate the performance of the Equator attachment as a MO retainer from a prosthodontic perspective during 2 years of loading and to investigate if the prosthodontics events can affect the OHRQoL.

Methodology

This longitudinal clinical study with 2 years of follow-up was conducted in the Complete Denture Clinic at the School of Dentistry/ Federal University of Pelotas (UFPel). The study was approved by the Ethics and Local Research Committee (UFPel, Approval number: 69/2013) and was conducted in accordance with the 2008 Declaration of Helsinki. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (STROBE). The G*Power software (available at http://www.gpower.hhu.de/) was used to calculate the sample size. The required sample size was estimated based on data from Marcello-Machado et al.[20] considering the global score of the OHIP-EDENT questionnaire (global score baseline: 11.48 ± 7.80; global score 1 year: 2.96 ± 4.72) and a priori t tests—Means: Wilcoxon signed-rank tests (matched pairs). The input parameters considered were: Two-tails, Parent distribution: min ARE, Effect size dz 1.25, α error probability 0.05, and Power (1-β error probability) 0.95. The minimum sample size required was 13. A 20% increase of the sample size to reduce the impact of patient withdrawal and loss to follow-up on study power resulted in a minimum final sample of 16 participants.

All patients invited to participate in the study received new complete dentures (CDs) at the Complete Denture Clinic in the School of Dentistry. The dentures were fabricated by undergraduate students under the supervision of two specialized professors (FF, LRP) 6 months prior to the study. A bilateral balanced occlusion scheme was adopted for prosthesis, in which 20 teeth were replaced (Trilux, VIPI Produtos Odontológicos, Brazil). Patients who reported difficulties in oral function after the prosthetic adaptation period were invited to participate in the study and to be installed an MO retained by two NDI (Facility-Equator system) (Figure 1). After the recruitment phase, patients were re-evaluated and treated during the follow-up period by researchers specialized in prosthodontics (two PhD students - RMM and AMB) who confirmed the adequate condition of the initial CD.

The implant system used was composed of grade V titanium (Facility NeoPoros surface - Neodent® - Curitiba, Brazil) with a diameter of 2.9 mm and length of 10 mm. The rehabilitation consisted of installing two NDI in the inter-foraminal region of the jaw, and the CD was transformed into an MO. Informed consent was obtained from all individual participants included in the study.

Patients of both sexes were selected to participate in the study without age restriction using the following inclusion criteria: users of new CDs confected at the Prosthodontics Clinic in the School of Dentistry and that have been in constant use for at least 3 months, time of edentulism and CD use

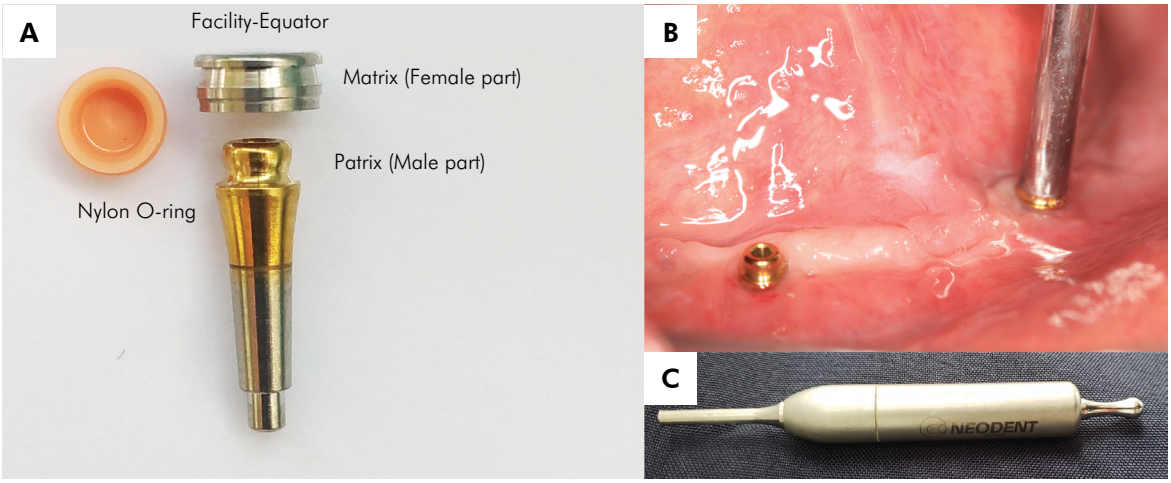

Figure 1. Facility-Equator attachment system: a) Facility-Equator Attachment, O-ring with cylinder, O-ring Equator pink; b) intra-oral view of the Equator attachment; c) Facility abutment placement aid.

of at least 5 years, experience lack of retention and stability, have limitations in residual ridge thickness contraindicating treatment with conventional diameter implants, have a minimum of 10 mm of mandibular height evaluated by panoramic radiography and a minimum of 3.5 mm thickness evaluated by teleradiographs established to select a patient with bone beds able to receive narrow diameter implants (Facility implants), have clinical atrophy with poor conditions of the supporting tissues (based on shape, tissue resilience, and the location of the muscle attachment) as identified by the criteria of Kapur,[20] available to come to the clinic on evaluation days, and present a good general health status. All patients should have abilities that make them apt to adequately complete the treatment and follow-ups, including motor skills, speech and language, understanding, perception of treatment, memory, interpretation, and interaction. The following exclusion criteria were used: history of radiotherapy in the head or neck region, prior history of oral implant insertion, treatment with bisphosphonate in the past 12 months, severe oral manifestations of systemic diseases, severe diabetes (hyperglycemia or inadequate glycemic control), bleeding disorders, severe systemic diseases, or psychological conditions that could influence the data collection.

After the adaptation period of the CD, preoperative panoramic radiographs and lateral cephalograms were performed for surgical planning. To evaluate the oral health-related quality of life (OHRQoL), each individual answered the self-perceived oral health questionnaire—Geriatric Oral Health Assessment Index (GOHAI) and the quality of life questionnaire—Oral Health Impact Profile Questionnaire (OHIP-EDENT), as described in the studies by Marcello-Machado et al.[19] Schuster et al.[21] After administering the questionnaire, an experienced surgeon performed the installation of two NDI and healing attachments in the inter-foraminal region of the mandible, followed by lower denture rebasing. The healing attachments were maintained for three months when prosthetic components with a "stud" type fitting (Equator - Neodent) were installed for the MO loading. The Equator attachment was installed with aid of a hammer. After MO loading, the hammer was positioned on the prosthetic seating area, and the attachment was struck three times to ensure frictional retention.[3] The following recommendations were given to patients for adequate use of the MO: During insertion, they were instructed to always fit the prosthesis over the Equator attachments using their hands, and they were also advised against using the mandibular prosthesis to fit the attachment to the O-ring through biting. Patients were also instructed to use their fingers to press the prosthesis flange in the occlusal direction in order to remove the prosthesis. Annual periodic follow-ups at one and two years after MO loading were prospectively scheduled for oral cavity examination and OHRQoL evaluation. Medical history and prosthodontic events related to prosthodontic maintenance or complications that occurred throughout this period were recorded and reviewed at the end of the study. The complications correspond to unexpected events that can generate injuries and interruption of prosthesis usage, while the prosthodontic maintenance events refer to routine maintenance events associated with overdenture use.

The following data were analyzed: prosthodontic complications related to prosthetic component dislodgement (loss of the healing attachment, Equator attachment, or female part –matrix), fracture of the mandibular prosthesis, fabrication of new overdenture, replacement of the Equator attachment to adjust the transmucosal height, artificial tooth fracture, replacement of the matrix (female), tissue reopening for attachment replacement, vestibular deepening surgery, and removal of the peri-implant keratinized mucosa (excision of a minimal amount of keratinized tissue, allowing passive seating of the prosthesis without injuries), and need for prosthesis rebasing. Prosthodontic maintenance events such as pink O-ring exchange and prosthesis adjustments were also recorded.

Statistical analysis was performed using the SPSS 22 software (IBM SPSS Statistics 22, Armonk, USA), and a significant difference was defined as $p < 0.05$ for all analyses. Descriptive analysis was performed to evaluate the distribution of the data. Prosthetic events were considered independent variables, while the scores of the domains obtained

through the OHRQoL questionnaire assessment were considered dependent variables. As the data from the OHRQoL questionnaires had a non-normal distribution, non-parametric tests were used, in which the individuals themselves were considered their own controls in the baseline (paired test). Paired Wilcoxon test was used for comparisons of each domain of the OHIP-EDENT and GOHAI questionnaires over time. Mann-Whitney test was used to evaluate the effect of the prosthetic events in each period (one year and two years after loading) on the domain scores; for each patient, the events were categorized as present or absent for each prosthodontic complication and/or maintenance event. Spearman's correlation coefficient was used to evaluate correlations between the patients that had one or more events of all prosthodontic complications and maintenance events and the scores of the GOHAI and OHIP-EDENT questionnaire domains.

Results

The sample consisted of 24 participants with a mean age of 68.1 (± 7.51) years; 17 women with mean mandibular and maxillary time since edentulism of 28.44 and 31.88 years, respectively, and 7 men with mean mandibular and maxillary time since edentulism of 16.14 and 27.71 years, respectively. After the first year, 1 patient was lost to follow-up, and the sample consisted of 23 participants. Table 1 shows the sociodemographic characteristics of the sample. Table 2 shows the distribution of the prosthodontic complications and maintenance events observed in the first and second years of MO loading as well as the corresponding number of patients. In the first year, 127 events were recorded, including 91 prosthodontic complications (71.75%) and 36 prosthodontic maintenance events (28.35%). Considering all events in this period, the most frequent events included Equator dislodgement (14.17%), prosthesis adjustments (16.54%), and nylon retainer (O-ring) exchange (11.81%). The events with the lowest incidence in the first year were vestibular deepening surgery (0.79%), matrix (female) dislodgement (0.79%), and new overdenture confection (2.36%). In the second year, 87 events were

Table 1. Socio-demographic information of the patients.

Variables	n
Sex (female/male)	
Male	7
Female	17
Race	
White	22
Black	1
Asian	1
Age (mean, years)	68.08
Time since edentulism (mean, years)	
Time since edentulism – maxilla	31.79
Time since edentulism - mandible	25.83
Marital status	
Single	4
Married	13
Divorced	3
Widow	4
Level of education	
Incomplete elementary school	15
Complete elementary school	3
Incomplete high school	1
Complete high school	3
Incomplete higher education	1
Complete higher education	1
Monthly income (in Brazilian minimum wages)	
≤ 1	18
> 1 and ≤ 2	3
> 2 and ≤ 3	3
Residence	
Urban	21
Rural	3
Actual work situation	
Working	9
Not working/Retired	15
Number of medical conditions and diseases	
0–1	9
2	5
≥ 3	10
Comorbidity conditions	
Diabetes mellitus (Yes)	7
Hypertension (Yes)	14
Arthritis (Yes)	3
Psychiatric disorders (Yes)	4
Smoke (Yes)	3

observed, including 45 prosthodontic complications (51.7%) and 42 prosthodontic maintenance events (48.3%). Of all events, the most frequent events were related to prosthesis adjustment (27.59%), nylon retainer (O-rings) exchange (20.69%), and female part recapture (11.49%). The least common complications in this period were tissue reopening for attachment replacement (1.15%), removal of peri-implant keratinized mucosa (1.15%), and female part dislodgement (1.15%).

Table 3 lists the means and standard deviations of the scores of the OHIP-EDENT and GOHAI domains before, 1 year after, and 2 years after MO loading. Most domains of both OHRQoL questionnaires had significant differences ($p < 0.05$) between the baseline and MO post-loading periods, except for the Social Disability and Psychological Discomfort domains of the OHIP-EDENT questionnaire that only showed a significant reduction after the first year. Significant differences ($p < 0.05$) were not observed between the 1- and 2-year assessments for any domain of either questionnaire.

Tables 4 and 5 list the Spearman correlation coefficients between the questionnaire domains and the prosthodontics maintenance and complications events. For the GOHAI questionnaire, negative correlations were observed between the Equator dislodgement and the Physical ($r = -0.415$; $p = 0.044$) and Pain and Discomfort ($r = -0.495$; $p = 0.014$) domains, between prosthesis fracture and the Psychosocial ($r = -0.424$; $p = 0.039$) domain 1 year after MO loading, and between removal of keratinized mucosa and the global score ($r = -0.440$; $p = 0.031$) (Table 4). After 2 years, prosthesis rebasing and the Pain and Discomfort domain ($r = -0.772$; $p < 0.001$) and global score ($r = -0.635$; $p = 0.001$) showed significant negative correlations (Table 4). In the OHIP-EDENT questionnaire, a positive correlation was observed between the Equator dislodgement and the Physical Pain domain ($r = 0.470$; $p = 0.020$)

Table 2. Type, number of patients, number of events and relative percentage of events during the first and second years of occlusal loading.

Variables	During first year (n = 24)			During second year (n =23)		
	n (patients)	n (events)	%	n (patients)	n (events)	%
Complications						
Healing abutment dislodgement	4	7	5.51	-	-	-
Equator dislodgement	6	18	14.17	2	3	3.45
Matrix (Female) dislodgement	1	1	0.79	1	1	1.15
Prosthesis fracture	4	4	3.15	4	4	4.60
New overdenture	3	3	2.36	8	8	9.20
Equator change (Transmucosal length)	3	6	4.72	2	2	2.30
Matrix (Female) recapture	9	14	11.02	8	10	11.49
Teeth fracture	2	6	4.72	3	3	3.45
Matrix (Female) change	5	5	3.94	2	2	2.30
Reopening for abutment replacement	4	10	7.87	1	1	1.15
Vestibular deepening surgery	1	1	0.79	1	1	1.15
Removal of keratinized mucosa	6	8	6.30	1	1	1.15
Prosthesis rebasing	8	9	7.10	6	9	10.34
Total		91			45	
Maintenance						
Prosthesis adjustment	13	21	16.54	8	24	27.59
Nylon O-ring change	13	15	11.81	13	18	20.69
Total		36			42	

Table 3. Means and standard deviations of the OHIP-EDENT and GOHAI questionnaire domain scores before, after 1 year and after 2 years of MO loading. (Wilcoxon Paired Test, $p < 0.05$).

Variable	Baseline (n = 24)	1 year (n = 24)	2 years (n = 23)	p-value baseline – 1year	p-value baseline – 2years	p-value 1year – 2years
OHIP-EDENT						
Global	11.13 ± 7.43	2.42 ± 2.67	2.04 ± 3.13	≤ 0.0001	≤0.0001	0.149
Functional Limitation	3.43 ± 1.81	0.96 ± 0.91	0.96 ± 1.3	≤ 0.0001	≤0.0001	0.745
Physical pain	3.52 ± 2.3	0.75 ± 1.07	0.48 ± 1.12	≤ 0.0001	≤0.0001	0.228
Psychological discomfort	0.87 ± 1.24	0.21 ± 0.66	0.17 ± 0.49	0.050	0.022	0.854
Physical disability	1.78 ± 1.5	0.25 ± 0.53	0.35 ± 0.65	≤ 0.0001	0.001	0.317
Psychological disability	0.61 ± 0.78	0.08 ± 0.28	0.04 ± 0.21	0.006	0.004	0.317
Social disability	0.52 ± 0.88	0.13 ± 0.34	0 ± 0	0.064	0.016	0.083
Handicap	0.52 ± 0.88	0.04 ± 0.2	0 ± 0	0.015	0.016	0.317
GOHAI						
Global	27.54 ± 2.6	29.58 ± 0.88	29.39 ± 1.03	0.001	0.002	0.667
Physical	8.42 ± 1.47	9.79 ± 0.41	9.78 ± 0.52	≤ 0.0001	0.001	1
Psychosocial	11.54 ± 1.56	12.88 ± 0.34	13.0 ± 0.0	0.001	0.001	0.083
Pain and discomfort	7.58 ± 0.88	6.92 ± 0.5	6.83 ± 0.39	0.002	0.001	0.414

OHIP-EDENT: oral health impact profile; GOHAI: geriatric oral health assessment index

and between prosthesis fracture and the Physical Pain ($r = 0.583$; $p = 0.003$) and Handicap ($r = 0.466$; $p = 0.022$) domains 1 year after loading (Table 5). After 2 years, the confection of new overdentures and the global scores were positively correlated ($r = 0.447$; $p = 0.033$), as well as the vestibular deepening surgery and the Physical Pain ($r = 0.460$; $p= 0.027$), psychological discomfort ($r = 0.604$; $p = 0.002$), and Physical Disability ($r = 0.439$; $p = 0.036$) domain scores (Table 5).

Figures 2 and 3 shows the graphical representation of the statistically significant influence of the presence of events on the domains of the GOHAI and OHIP-EDENT questionnaires. Equator dislodgement negatively influenced the Physical ($p = 0.047$) and Pain and Discomfort ($p = 0.018$) domains of the GOHAI questionnaire (Figure 2a) and the Physical Pain ($p = 0.024$) domain of the OHIP-EDENT questionnaire (Figure 3a) in the first year of MO loading. Fracturing of the prosthesis significantly influenced MO loading in the Psychosocial ($p = 0.042$) domain of the GOHAI questionnaire (Figure 2b) and the Handicap ($p = 0.0025$) and Physical Pain ($p = 0.005$) domains of the OHIP-EDENT questionnaire (Figure 3b) in the same period. The removal of keratinized mucosa also negatively influenced the global score ($p = 0.035$) of GOHAI (Figure 2c) in 1 year. After 2 years, prosthesis rebasing negatively influenced the Pain and Discomfort ($p < 0.001$) domain and the global ($p = 0.003$) GOHAI questionnaire score (Figure 2d). The confection of a new overdenture also negatively influenced the global score ($p = 0.036$) (Figure 3c), and the vestibular deepening surgery influenced the OHIP-EDENT scores in the Physical Pain ($p = 0.031$), Psychological Discomfort ($p = 0.005$) and Physical Disability domains ($p = 0.004$) (Figure 3d) in the second year of MO loading. The other events did not show significant results in any evaluation period.

Discussion

In this study, we verified that the prosthetic behavior of the Facility implant system and the Equator attachment retained by a friction mechanism can generate a greater number of prosthetic occurrences related to prosthodontic complications and maintenance events in the first year of MO loading compared to the second year, and that certain complications may affect patients' OHRQoL. These findings suggest that the OHRQoL is influenced by the

Table 4. Spearman correlation between the GOHAI questionnaire domains and prosthetic events after 1 and 2 years of MO loading.

Variable		1 Year				2 Years			
GOHAI domains/ Prosthetic events		Physical	Psychosocial	Pain and discomfort	Global	Physical	Psychosocial	Pain and discomfort	Global
Healing abutment dislodgement	R =	-0.235	0.119	-0.091	-0.212	-	-	-	-
	P =	0.268	0.350	0.673	0.319	-	-	-	-
Equator dislodgement	R =	-0.415	-0.073	-0.495	-0.374	0.141	-	0.142	0.220
	p =	0.044	0.736	0.014	0.072	0.521	-	0.519	0.313
Matrix (Female) dislodgement	R =	0.120	0.093	0.056	0.108	0.112	0.083	0.042	0.114
	P =	0.577	0.666	0.793	0.615	0.610	0.708	0.850	0.605
Prosthesis fracture	R =	-0.300	-0.424	-0.161	0.166	0.131	-	0.211	0.061
	p =	0.155	0.039	0.451	0.590	0.551	-	0.335	0.781
New overdenture	R =	0.217	0.169	0.102	0.196	0.167	-	-0.147	-0.268
	p =	0.309	0.431	0.634	0.359	0.446	-	0.504	0.216
Equator change (Transmucosal length)	R =	-0.060	-0.154	-0.136	-0.120	0.163	0.120	0.060	0.165
	p =	0.780	0.471	0.525	0.578	0.458	0.587	0.784	0.453
Matrix (Female) recapture	R =	-0.026	-0.228	-0.213	-0.156	-0.334	-	-0.279	-0.189
	p =	0.902	0.285	0.317	0.466	0.119	-	0.197	0.388
Teeth fracture	R =	-0.245	-0.319	-0.272	0.156	0.204	0.150	0.076	0.207
	p =	0.248	0.128	0.198	0.466	0.350	0.495	0.731	0.344
Matrix (Female) change	R =	0.069	0.229	-0.056	0.035	-0.141	-	-0.565	-0.041
	p =	0.150	0.282	0.797	0.869	0.521	-	0.221	0.852
Reopening for abutment replacement	R =	-0.235	0.199	-0.303	-0.270	0.163	0.120	0.348	0.384
	p =	0.268	0.350	0.150	0.201	0.458	0.587	0.104	0.070
Vestibular deepening surgery	R =	0.107	0.079	0.040	0.108	0.112	0.083	-0.397	-0.247
	p =	0.619	0.714	0.854	0.615	0.610	0.708	0.061	0.257
Removal of keratinized mucosa	R =	-0.178	-0.364	-0.294	-0.440	0.112	0.083	0.042	0.114
	p =	0.406	0.081	0.164	0.031	0.610	0.708	0.850	0.605
Prosthesis rebase	R =	-0.178	0.089	-0.144	-0.206	-0.023	-	-0.772	-0.635
	p =	0.406	0.680	0.503	0.334	0.918	-	0.000	0.001
Prosthesis adjustment	R =	-0.60	-0.95	-0.159	-123	-0.104	-	0.094	0.238
	p =	0.780	0.659	0.457	0.568	0.636	-	0.669	0.274
Nylon O-ring change	R =	-0.060	-0.348	0.175	0.000	-0.080	-	0.292	0.078
	p =	0.780	0.096	0.412	1.000	0.716	-	0.177	1.000

R: correlation coeficient; p: p-value.

prosthetic events that make it impossible to wear and retain the prosthesis, such as Equator dislodgement and prosthesis fracture, requiring new overdenture confection, and by complications that cause pain to the support tissues, such as maladaptation of the prosthesis and the need for prosthesis rebasing. However, these complications are inherent to any type of non-splinted attachment system.

Studies have shown that regardless of the attachment type used as a retainer, the highest number of prosthesis adjustments and maintenance needs occur in the first year of MO loading.[17,22] In our study, the incidence of prosthetic events was 31.49% higher in the first year than in the second year. This reduction in events in the second year occurred due to a decrease in prosthetic complications, as

Table 5. Spearman correlation between the OHIP-EDENT questionnaire domains and prosthetic events after 1 and 2 years of MO loading.

OHIP-EDENT		1 Year								2 Years							
		Functional limitation	Physical pain	Psychological discomfort	Physical disability	Psychological disability	Social disability	Handicap	Global	Functional limitation	Physical pain	Psychological discomfort	Physical disability	Psychological disability	Social disability	Handicap	Global
Healing abutment dislodgement	r =	-0.247	0.245	-0.199	-0.228	-0.135	0.169	-	-0.033								
	p =	0.244	0.248	0.350	0.283	0.530	0.430	-	0.878								
Equator dislodgement	r =	0.272	0.470	0.060	0.206	0.174	0.364	-0.120	0.398	0.103	-0.181	-0.119	0.136	-0.066	-	-	0.038
	p =	0.199	0.020	0.779	0.333	0.416	0.081	0.575	0.054	0.639	0.407	0.588	0.536	0.765	-	-	0.864
Matrix (Female) dislodgement	r =	-0.239	-0.170	-0.79	-0.106	-0.063	-0.79	-0.043	-0.262	0.196	0.313	-0.082	0.313	-0.045	-	-	0.243
	p =	0.261	0.427	0.715	0.620	0.770	0.714	0.840	0.217	0.370	0.145	0.709	0.145	0.837	-	-	0.263
Prosthesis fracture	r =	0.282	0.583	0.155	0.091	-0.135	0.169	0.466	0.380	0.086	0.202	-0.177	0.270	-0.098	-	-	0.103
	p =	0.183	0.003	0.471	0.671	0.530	0.430	0.022	0.067	0.695	0.355	0.418	0.213	0.657	-	-	0.640
New overdenture	r =	-0.269	0.147	-0.169	-0.193	-0.114	-0.143	-	-0.037	0.412	0.367	-0.024	0.376	0.292	-	-	0.447
	p =	0.203	0.492	0.431	0.366	0.596	0.505	-	0.863	0.051	0.085	0.915	0.077	0.176	-	-	0.033
Equator change	r =	0.029	0.185	0.222	0.167	-0.114	0.238	-0.079	0.139	0.103	-0.181	-0.119	0.136	-0.066	-	-	0.038
	p =	0.894	0.387	0.298	0.435	0.596	0.263	0.714	0.516	0.639	0.407	0.588	0.536	0.765	-	-	0.864
Matrix (Female) recapture	r =	-0.072	-0.186	0.238	-0.149	0.078	0.228	-0.234	-0.006	-0.252	0.197	0.270	-0.188	-0.156	-	-	-0.156
	p =	0.738	0.385	0.263	0.486	0.718	0.285	0.272	0.977	0.246	0.368	0.212	0.391	0.478	-	-	0.476
Teeth fracture	r =	0.012	0.246	-0.114	-0.154	-0.091	-0.114	-0.063	0.780	-0.097	-0.228	-0.150	-0.228	-0.083	-	-	-0.168
	p =	0.957	0.247	0.597	0.472	0.673	0.596	0.770	0.718	0.656	0.295	0.495	0.296	0.708	-	-	0.442
Matrix (Female) change	r =	-0.078	0.171	-0.229	-0.262	-0.155	0.116	-	0.053	0.155	0.242	0.378	0.227	-0.066	-	-	0.138
	p =	0.716	0.423	0.282	0.216	0.471	0.588	-	0.806	0.481	0.266	0.076	0.298	0.765	-	-	0.529
Reopening for abutment replacement	r =	0.043	0.219	-0.169	0.034	0.270	0.169	-0.093	0.182	0.297	0.136	0.318	0.136	-0.066	-	-	0.302
	p =	0.843	0.305	0.431	0.874	0.203	0.430	0.665	0.396	0.169	0.536	0.139	0.536	0.765	-	-	0.161
Vestibular deepening surgery	r =	0.255	0.238	-0.079	-0.106	-0.063	-0.079	-0.043	0.169	0.392	0.460	0.604	0.439	-0.045	-	-	0.383
	p =	0.230	0.263	0.715	0.620	0.770	0.714	0.840	0.429	0.064	0.027	0.002	0.036	0.837	-	-	0.072
Removal of keratinized mucosa	r =	0.066	-0.094	0.375	0.206	0.174	0.073	-0.120	0.149	0.416	-0.125	-0.082	-0.125	-0.045	-	-	-0.191
	p =	0.759	0.662	0.071	0.333	0.416	0.736	0.575	0.487		0.596	0.709	0.569	0.837	-	-	0.382
Prosthesis rebasing	r =	-0.142	-0.126	0.138	0.099	0.107	0.000	-	-0.163	0.066	0.330	0.370	-0.087	-0.127	-	-	0.145
	p =	0.509	0.559	0.520	0.644	0.620	1.000	-	0.445	0.764	0.124	0.082	0.692	0.565	-	-	0.508
Prosthesis adjustment	r =	-0.172	0.189	0.158	0.273	-0.025	-0.158	-	-0.031	-0.122	-0.241	-0.024	-0.242	-0.156	-	-	-0.186
	p =	0.421	0.377	0.460	0.1960	0.907	0.461	-	0.886	0.579	0.267	0.915	0.267	0.478	-	-	0.395
Nylon O-ring change	r =	0.332	0.150	0.347	0.077	-0.025	0.348	0.192	0.290	-0.374	-0.086	0.056	-0.309	0.187	-	-	-0.265
	p =	0.130	0.485	0.097	0.721	0.907	0.096	0.369	0.169	0.079	0.697	0.798	0.151	0.393	-	-	0.222

OHIP-EDENT: oral health impact profile

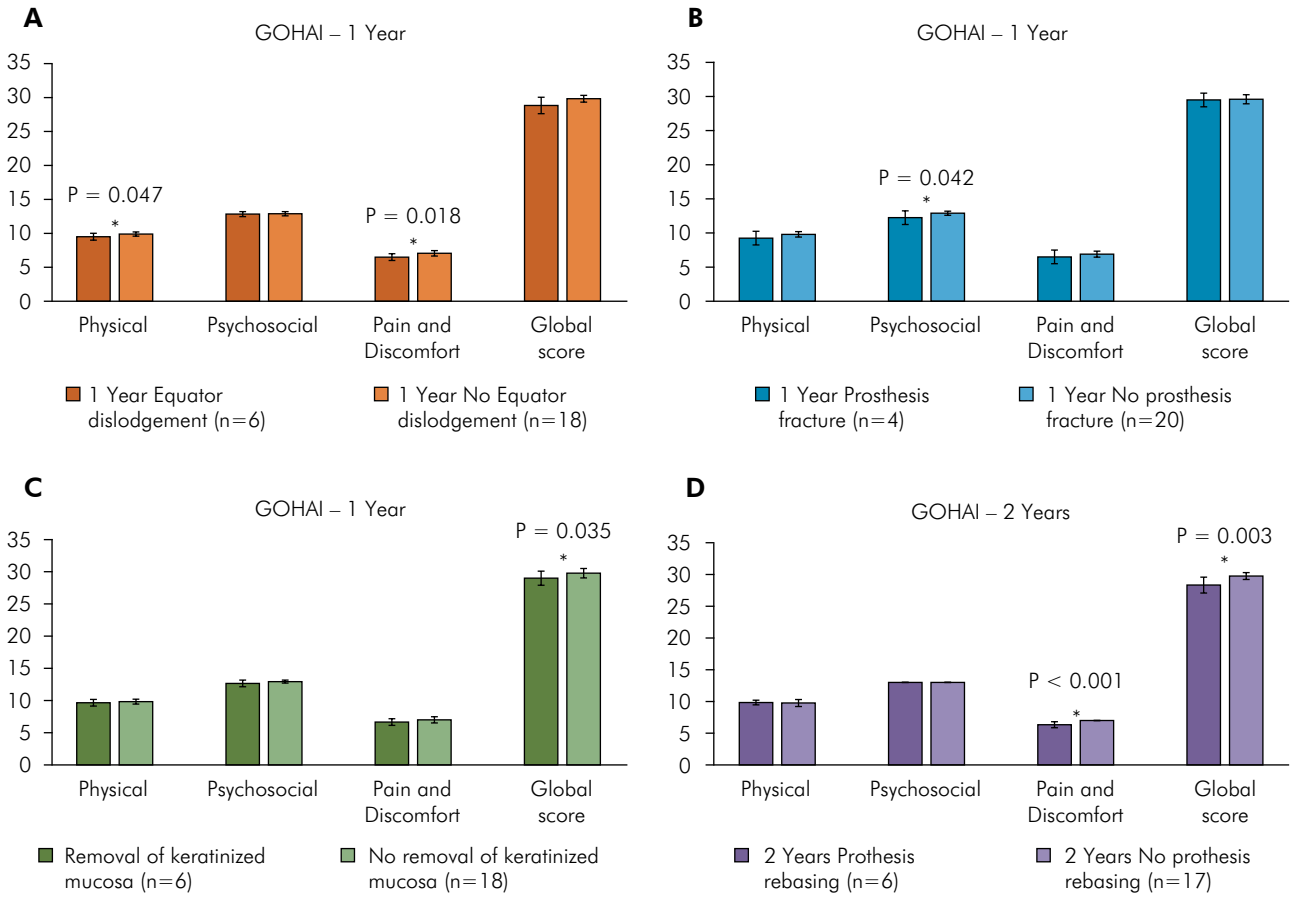

Figure 2. Influence of prosthetic events on the GOHAI questionnaire domains that had statically significant differences in the Mann-Whitney test ($p < 0.05$). One Year: a) Equator dislodgement influenced the Physical and Pain and Discomfort domains; b) Prosthesis fracture influenced the Psychosocial domain; c) Removal of keratinized mucosa influenced the global score. Two Years: d) Prosthesis rebasing influenced the Pain and Discomfort domain and the global score.

we observed a 14.28% increase in maintenance events during this period (O-ring exchange and prosthesis adjustment).

During the first two years, the most prevalent prosthetic occurrences were prosthesis adjustments (16.54% and 27.59%, respectively), amounting to 1.6 adjustments per patient in the first year (13 patients) and 3 adjustments per patient in the second year (8 patients). In our sample, mandibular prosthesis adjustment in the second year was recurrent in some individuals. A study that used a two-piece Locator mini-implant system in a sample of 25 patients also reported that the main maintenance event observed after 1 year of MO loading was denture adjustment, followed by replacement of nylon O-rings.[23] Therefore, we suggest that individual characteristics, such as advanced residual ridge resorption and contact of the prosthesis base with flaccid tissues in the area, can lead to mucosal injury even when using MO, thereby requiring frequent readjustments of the mandibular prosthesis base. Chaffe et al.[24] observed that the mean time until the first adjustment of the prosthesis base for ball-type attachments was 89.5 days, and the mean number of adjustments per patient in their study was 1.49 in the follow-up period of 36 months. In our study, the number of prosthesis base adjustments per affected patient was 2.81 after 2 years.

Equator attachment dislodgement was the second most prevalent event in the first year after MO loading (14.17%). This high number of occurrences (18 events) was probably due to three clinical factors: a) the Facility-Equator system is a cone morse

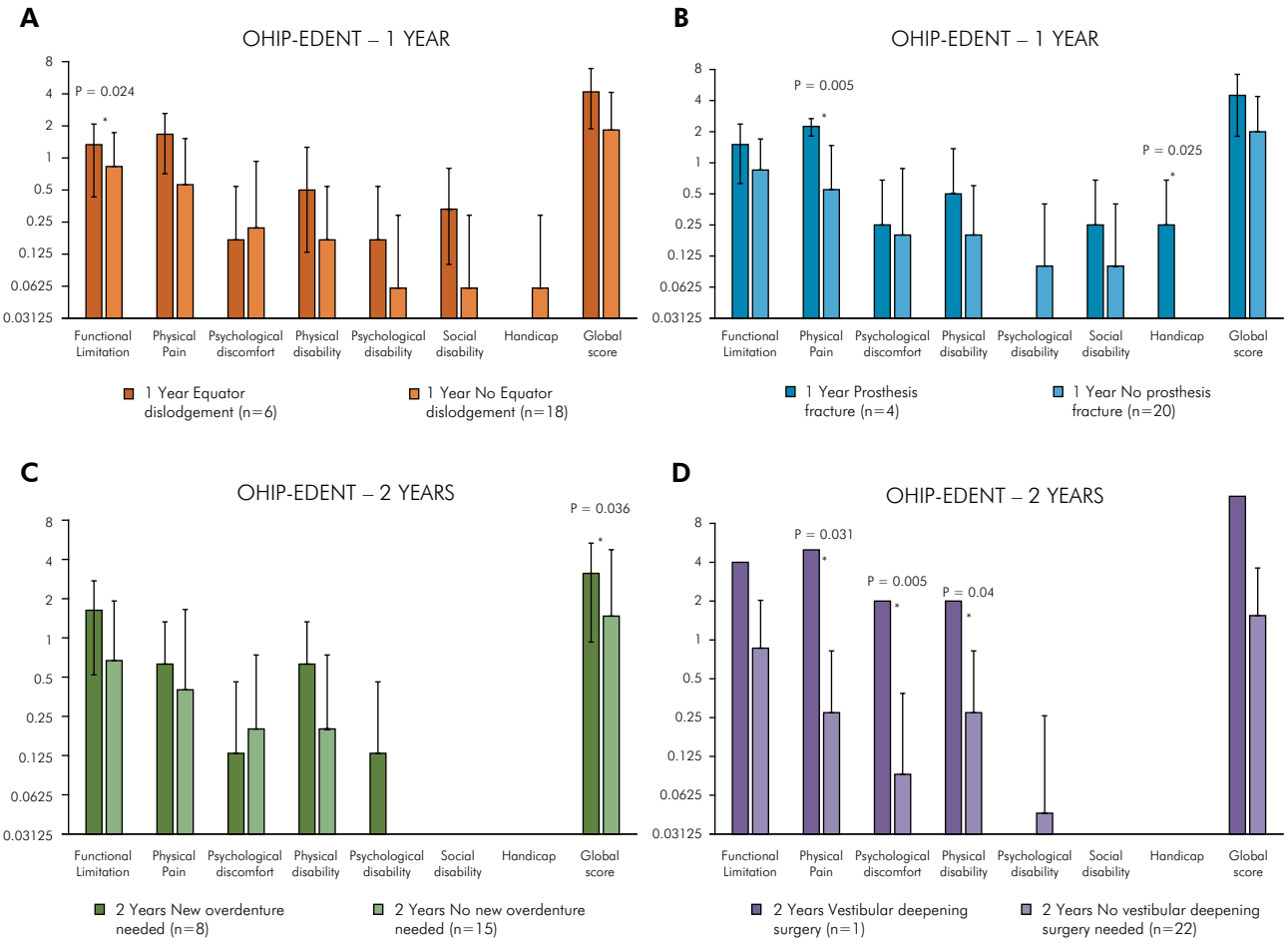

Figure 3. Influence of prosthetic events on the OHIP-EDENT questionnaire domains that had statically significant differences in the Mann-Whitney test ($p < 0.05$): One Year: a) Equator dislodgement influenced the Physical Pain domain; b) Prosthesis fracture influenced the Handicap and Physical Pain domains. Two Years: c) New overdenture confection influenced the global score; d) Vestibular deepening surgery influenced the Physical Pain, Psychological Discomfort, and Physical Disability domains.

connection retained by a pure frictional force, and not by internal threads as seen in other systems for conventional diameter implants, which may contribute to the frequent attachment dislodgement; b) The Equator attachments were installed at the peri-implant soft tissue level to ensure stable peri-implant seal formation; however, one limitation of the system is that the manufacturer presents components with different length ($\Delta = 1$ mm) in its catalog, and the decision was made to use a shorter component and wait for the adaptation of the mucosa, and c) the formation of a large amount of highly keratinized and resistant mucosa observed around the implants after implant insertion; the soft tissues adjacent to the bone tissue undergo an adaptation process to promote the sealing of the mucosa around the implant and prosthetic attachment.[25] This period of mucosal adaptation with the formation of keratinized mucosa may thus have influenced the recurrent loss of prosthesis retention by the Equator attachment expulsion and dislodgement in the first year of follow-up. However, in the second year, this event occurred in only 2 patients, therefore showing the adaptation of the mucosa and stabilization of the attachment.

Nylon O-ring replacement was the third most common prosthetic occurrence in the first year (11.81%) and the second most common event in the second year (20.69%). Studies have shown that the nylon retainer used in button-type attachments wears down

significantly over time,[26] and the deformation in the center of the rubber is more evident, as previously reported by fatigue tests.[27] O-ring replacement was also the most frequent maintenance event in a study investigating the clinical maintenance of Locator attachments and mini diameter implants in the first year of MO loading,[23] which has similar sample size and implant characteristics as the present study. The second most common event in the study by Mifsud et al.[23] was the change of the nylon insert. Ab Nader et al.[28] observed that mastication reduced the Locator rubber retention by 40% with several alterations, such as a light degree of wear on internal surfaces of the ball-type retainer in their *in vitro* study. Finally, the significant decrease in the retention values of the Locator rubber over time was also attributed to the recurrent insertion and removal of the prosthesis.[28,29] In our study, 31.25% of the nylon rings lost their retention in the first year and 39.13% in the second year, and 10% of the nylon rings that were replaced in the second year were already replaced in the first year. Only five patients did not require any nylon ring replacement; therefore, 79% of patients had to perform at least one rubber exchange in two years of follow-up. Although the Locator and Equator systems are both button-type attachments, the observed wear in both systems appears to be different, but comparative studies are necessary to investigate the deformation during use.

The wear of the nylon O-rings may also be related to the recapturing of the female part (matrix), which was the third most prevalent prosthetic event (11.49%) observed in the second year of MO loading. Jo et al.[27] observed that the load applied to button-type connectors was relieved by the resilient nylon matrix, the connection to the top of the attachment, and the deformation of the prosthesis base. Consequently, the dissipation of the load exerted on the MO during speech and masticatory movements may be capable of deforming the prosthesis base and distorting the acrylic resin adjacent to the matrix, altering the matrix-attachment fit, thereby necessitating matrix recapture. Thus, the results of this study confirm previous findings demonstrating that a large number of technical procedures are necessary to maintain the overdentures in function over 1 year. In addition, the present study shows that prosthetics events decrease considerably after one year (−31.49%).

The combined use of 2 OHRQoL questionnaires in this study allows to evaluate the consistency of the OHRQoL results and allows a more detailed analysis, since both questionnaires focus on different aspects.[30,31] The OHIP-EDENT questionnaire gives a greater weight to psychological and behavioral outcomes and is therefore better at detecting Psychosocial impacts on OHRQoL along with prosthetic problems.[32] Meanwhile, the GOHAI questionnaire places more emphasis on functional limitations or Pain and Discomfort domains, allowing to evaluate the impact of minor clinical changes and immediate clinical aspects.[31,32] The results revealed that all domains of both OHRQoL questionnaires showed significant differences ($p < 0.05$) between the baseline evaluations and the MO post-loading assessments after 1 and 2 years, except for the Social Disability and Psychological Discomfort domains of the OHIP-EDENT questionnaire that only showed a difference after the first year of loading. These results corroborate earlier findings showing that patient satisfaction and OHRQoL increase significantly after MO installation, and remain stable over time regardless of the type of attachment system used.[22,26,33] Some maintenance events and prosthodontic complications occurring in the Facility-Equator system can affect the patients' OHRQoL during the first and second years post-loading, as all Spearman correlations were confirmed by the Mann-Whitney test (Tables 3, 4; Figures 2 and 3). The negative correlations observed for the GOHAI questionnaire indicate that patients who had more than one complication event had lower scores, representing a worse OHRQoL. Likewise, the positive correlations found in the OHIP-EDENT questionnaire indicate a higher domain score, reflecting a decrease in OHRQoL.

The events that affected the OHRQoL during the first year are those that impaired prosthesis retention, such as Equator's dislodgement and MO fracture. Equator dislodgement affected domains related to painful mouth sensation in both OHRQoL questionnaires, as this event causes inability to chew and swallow food comfortably

and discomfort during function. MO fracturing resulted in social discomfort and dissatisfaction with the treatment, since patients felt uncomfortable being with other people and eating in front of others. Mundt et al.[34] observed that prosthesis fracturing occurred in approximately one of five patients over a 4-year period, and recommended the use of metal structures for reinforcement. In our study, mandibular prosthesis fracturing was probably related to the reduced thickness of the inferior prosthesis flange fit to a mandibular arch morphology altered by advanced residual ridge resorption, as our patients had a prolonged duration of edentulism. In addition, we highlight that conventional CDs were converted into MO. Therefore, the design and biomechanics were aimed at providing retention, stability, and support of a muco-supported prosthesis, which, in association with the diameter of the internal connector (matrix of 4.5 mm Ø x 2 mm), may contribute to a greater fragility of the MO, as suggested by other authors.[35]

In the second year of MO loading, events like mandibular prosthesis rebasing and confection of new overdentures significantly affected the patients' OHRQoL. Prothesis rebasing affected the Pain and Discomfort domain of the GOHAI questionnaire that records painful sensations during chewing and the need for analgesics for pain relief. Attard et al.[36] reported that laboratory rebasing was required every four years for MO retained by conventional diameter implants. However, in our study, 13 of 24 patients needed rebasing in two years, 4 patients experienced two events, and 1 patient experienced three events. This condition demonstrates that bone remodeling among edentulous individuals is highly variable. Implant placement may promote changes in the bone and peri-implant soft tissues that necessitate rebasing to optimize the prosthesis adjustment and refine the acrylic denture base.[37]

The limitations of the present study include the absence of a control group. Most of the attachments available on the market for rehabilitation with MO over NDI are composed of a single piece or two-piece systems with components screwed to the implant, which impedes their use as a control for this study. Another limitation is the use of only one type of nylon rubber. The manufacturer offers nylon rings in different colors with different degrees of retention, pink, and violet; however, we opted to exclusively test the pink rubber to increase the internal consistency of the data. A larger sample size and a longer follow-up period may also provide more comprehensive results on the Facility-Equator system.

Conclusion

The results demonstrate that the MO retained by 2 NDI and Equator attachments were characterized by a greater number of prosthetic events in the first year of use; however, the treatment significantly improved the patients' OHRQoL. Prosthetic complications such as prosthesis fracture, prosthetic component dislodgement, prosthesis rebasing, and confection of new overdentures occurring during rehabilitations with Equator attachments can affect the OHRQoL, primarily via the Physical and Pain domains, indicating greater discomfort in the first year of MO loading.

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