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ORIGINAL ARTICLE

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Patient-reported outcomes following dental implant rehabilitation according to reason for missing teeth: A survey from a Norwegian population 8 years following treatment

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Abstract

Aim: The aim of this study was to assess patient-reported outcomes (PROs) 8 years after dental implant rehabilitation in a sample with tooth loss due to periodontitis (TLP) and a sample with missing teeth for other reasons (MTOR).

Materials and Methods: The Norwegian National Insurance Scheme registry of subsidized dental implant therapy was searched, and patients ($n = 3083$) rehabilitated with dental implants in 2014 were mailed a questionnaire. PROs were described by relative frequencies, and the TLP and MTOR subsamples were compared using chi-square test. Multiple linear regression analyses were used to investigate variables potentially predicting PROs.

Results: Of the respondents ($n = 1299$), more than 90% were partly or fully satisfied with the treatment outcome. Complications were reported by 44.2%. Patients who lost teeth due to periodontitis ($n = 784$) reported greater oral function improvement and better pre-treatment information, and were more likely to experience complications when compared with patients who lost teeth for other reasons ($n = 515$). Age, level of education, self-funded cost, pre-treatment information, history of complications and the reason for missing teeth were found to predict PROs.

Conclusions: In a Norwegian population rehabilitated with dental implants in 2014, satisfaction with the treatment outcome and the aesthetic outcome was high, irrespective of the reason for missing teeth. Self-report of complications and lack of pre-treatment information were the strongest predictors of inferior patient satisfaction and also predicted inferior oral function.

KEYWORDS
dental implant(s), oral rehabilitation, patient outcomes, patient satisfaction, peri-implant diseases

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Clinical relevance

Scientific rationale for study: Dental implant therapy is performed worldwide in different clinical settings. However, more knowledge on patient-reported outcomes following dental implant therapy is required.

Principal findings: Most patients were satisfied with the treatment outcome 8 years following dental implant rehabilitation. Increasing age, absence of complications and sufficient pre-treatment information predicted higher patient-reported satisfaction.

Practical implications: Most patients were satisfied following implant therapy. Age, level of education, self-funded cost, pre-treatment information and self-reported complications were identified as predictors of patient-reported outcomes. Clinicians should be aware of these factors in case selection, treatment planning and decision making.

1 | INTRODUCTION

Dental implants are widely used to replace missing teeth, and it is estimated that approximately 15 million dental implants are carried out annually (Klinge et al., 2018). Research on dental implants traditionally emphasizes clinical and radiographic parameters, and long-term survival rates of 90%–98% have been reported in prospective studies and meta-analyses (Howe et al., 2019; M. Roccuzzo et al., 2010; A. Roccuzzo et al., 2022; Simonis et al., 2010). During the last decades, interest in patient-reported outcome measures (PROMs) following dental implant therapy has emerged, and a recent consensus report advocated inclusion of PROMs in studies investigating outcomes of implant therapy (Feine et al., 2018). Patient satisfaction is an essential part of evaluation of the quality and effectiveness in health care (Afrashtehfar et al., 2020; Ware Jr et al., 1983). Studies have reported that approximately 90% of patients are satisfied with the treatment outcome 6–16 years following dental implant rehabilitation (Adler et al., 2016; Derks et al., 2015; Johannsen et al., 2012; Pjetursson et al., 2005; Simonis et al., 2010). Most studies have been performed in a university or in a private practice setting, often with rigid inclusion criteria, patient selection and strict follow-up protocols. These studies may therefore offer limited external validity. Only one study has assessed patient-reported outcomes (PROs) in a randomly selected large sample (Derks et al., 2015), and a systematic review recommended further research on dental implant treatment outcomes in large samples with adequate time of functioning (Derks & Tomasi, 2015).

No standardized questionnaire assessing PROs of dental implant treatment exists to date, which hampers comparison of results between studies. Several instruments have been developed to measure patient satisfaction with respect to oral health, but there is a lack of valid theory-based instruments measuring patient satisfaction related to outcomes of dental implant treatment (Nair et al., 2018). Questionnaires used in previous studies differ, not only in the number and content of included questions but also in response alternatives and how data based on questionnaire responses are analysed and presented (Adler et al., 2016; Derks et al., 2015; Pjetursson et al., 2005; Simonis et al., 2010). Development of a validated questionnaire on PROs following dental implant therapy would improve quality and reproducibility.

The Norwegian National Insurance Scheme (NNIS) subsidizes dental implant rehabilitation provided specific dental or health-specific conditions are met. Subsidy of implant rehabilitation requires that the implant surgery is performed by a specialist in periodontics or oral/maxillofacial surgery and the prosthetic treatment is performed by a specialist in prosthodontics or a general practitioner with at least 6 years of clinical experience and a designated course. The history of NNIS subsidies is available for research and health statistical analysis.

The primary aim of this study was to assess PROs 8 years following dental implant rehabilitation in patients with tooth loss due to periodontitis (TLP) as compared with patients with missing teeth for other reasons (MTOR). A secondary aim was to investigate potential predictors of PROs.

2 | MATERIALS AND METHODS

The study protocol was approved by the regional ethics committee (REK 137258/2020) and the Norwegian Centre for Research Data. The study is reported according to the STROBE guidelines for cross-sectional studies.

2.1 | Registry data information

Based on NNIS registry data, records of patients who underwent dental implant rehabilitation in the year 2014 were traced and grouped according to the reason for missing teeth: implant rehabilitation following tooth loss due to periodontitis (TLP) or implant rehabilitation to replace missing teeth lost for other reasons (MTOR), for example, trauma, caries following hyposalivation, tooth wear or congenitally missing teeth. Whether a tooth was considered lost as a result of periodontitis or for other reasons was decided by the dentists involved in the treatment of the individual patients of the sample in 2014. In NNIS, a unique treatment provision code is used when an implant is placed following tooth loss due to periodontitis, while a different treatment provision code is used when implant placement is performed to replace teeth missing for other reasons.

Data extraction was performed in July 2021. No information about oral status or prosthesis type was included in the extracted registry data.

2.2 | Treatment provision facilities

NNIS reimbursement applies to all clinical settings, which include private practice, public health clinics, hospitals and university clinics. The majority (73%) of dentists in Norway are in private practice (Statistics Norway, 2014), and 84.7% of dental specialists' annual work is performed in private clinics (Norwegian directory of health, 2017).

2.3 | Study population

All patients who received subsidies for implant rehabilitation residing in 11 out of 19 counties in Norway were included (for details, see Supplementary Figure 1, Appendix). These specific 11 counties were chosen because of a planned subsequent clinical examination of randomly selected respondents in six different cities, and only patients in reasonable vicinity to these cities were invited. The selected counties included 72.1% of the total Norwegian population (Statistics Norway, 2014).

The patients received a postal questionnaire and a consent form, the latter for permission to schedule a clinical examination. Prepaid return envelopes were enclosed. The patients could choose to return only the questionnaire. There was also an option of digital reply and consent through a QR code and a web address, both linked to an online submission form. Participation was voluntary.

2.4 | Questionnaire

A draft survey questionnaire was developed by adapting items from previous research on PROs related to general (Perera & Usgodaarachchi, 2009) and dental implant treatment (Derks et al., 2015; Layton & Walton, 2011; Pjetursson et al., 2005; Simonis et al., 2010).

Most questionnaire items were designed as statements, with response options on a 5-point Likert-scale ranging from fully disagree (1) to fully agree (5). The draft questionnaire was pre-tested in two steps: First, it was evaluated by an expert group comprised of specialists in periodontology, periodontal and implant research and survey research experts. Next, it was tested on 10 patients with dental implants. Revisions were made based on feedback from both steps.

The final questionnaire included items assessing overall patient satisfaction, aesthetic outcome, oral functionality, cleansability of implant-supported prosthesis, side effects, knowledge/information about treatment alternatives and follow-up care, treatment decision making, cost–benefit, intention to undergo the same treatment again if necessary, the match between expectations and outcome, perceived outcomes of the treatment and complications. The questionnaire also included the following background variables: age, sex, nationality, number of dental implants and self-funded cost of the dental implant rehabilitation. Questionnaire items are available in Appendix (Supplementary Table 1).

The questionnaire was mailed in November 2021, and a reminder was sent 6 weeks later.

2.5 | Descriptive statistics

Descriptive analyses included relative frequencies and calculation of means and standard deviations for categorical and continuous variables, respectively. Differences between the TLP and MTOR samples were assessed by chi-square tests for categorical outcome measures and independent-sample *t*-tests for continuous outcome measures.

2.6 | Factor analysis

Exploratory factor analysis was performed to investigate the dimensional structure of the questionnaire items measuring PROs and to condense the data before further analyses. The recommendations of Hair et al. (2010) for testing the appropriateness of the data for factor analysis were used: a correlation matrix with coefficients >0.30, a Kaiser-Meyer-Olkin test (KMO) value >0.60 and a significant Bartlett's test ($p < .05$). Further, a combination of the Kaiser criterion (eigenvalue > 1) (Kaiser, 1960) and the scree plot test (Cattell, 1966) was used to determine the factor structure of the data. In the current analyses, factor loadings ≥0.50 on assigned factor was used as a criterion for convergent validity and factor loadings <0.5 as a criterion for discriminant validity. Internal consistency reliability for factors resulting from factor analysis was tested using Cronbach's-α, with α ≥0.70 considered good (Field, 2013).

2.7 | Regression analysis

Separate multiple linear regression models were run to investigate predictors of relevant PROs in the two sub-samples following factor analysis. The following independent variables were considered as predictors for both models: sex (reference category: male), age, level of education (reference category: not completed any education), extent of therapy (reference category: one implant), technical complication(s) (reference category: absence), biological complication(s) (reference category: absence), self-funded cost (reference category: < €2000), reason for missing teeth (reference category: MTOR) and potential relevant predictors following factor analysis. Bivariate correlation analyses were performed to test for multi-collinearity between independent variables. A cut-off value ≥0.80 for multi-collinearity was defined, as suggested by Haerens et al. (2008). Two-way interactions were also considered for the regression analysis.

The independent variables were entered in linear regression models with backward elimination, and non-significant ($p > .10$) variables were sequentially removed until the final models were retrieved. Assumptions for multiple linear regression models were assessed. As suggested by Kline (2015), cut-off values of 3.0 and 8.0 for skewness

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and kurtosis, respectively, were applied as a test of normality, and residual distributions were investigated.

All statistical analysis were conducted using IBM SPSS Statistics for Windows, version 27.0 (IBM SPSS Statistics, Armonk, NY, USA). The level of statistical significance was set at $p < .05$.

3 | RESULTS

3.1 | Sample characteristics

A total of 3324 patients received subsidized implant rehabilitation in the 11 included counties in 2014. The average age of the patients was 65 years, and 53.3% were female. The TLP sample consisted of 1973 patients with an average age of 72 years (56.8% female) and the MTOR sample had 1351 patients with average age 54.9 years (48.2% female). Since 2014, some patients ($n = 241$) had died or moved abroad, and thus 3083 were eligible for participation (Figure 1). Details of the total sample as compared with responders are available in the Appendix (Supplementary Table 2).

The response rate was 45.1% ($n = 784$) in the TLP sample and 41.6% ($n = 515$) in the MTOR sample. A flow-chart of the sampling process is provided in Figure 1.

Demographic variables of the respondents and the extent of implant therapy are shown in Table 1. Patients in the TLP sample had significantly more implants done ($p < .001$).

3.2 | Questionnaire item frequency distribution

The relative frequencies for the questionnaire items are presented in Table 2. For questionnaire items Q4–Q8 and Q11–Q12, TLP patients presented a significantly higher agreement with the statements.

Self-reported complications are presented in Figure 2, which describes the proportion of patients who reported none, one or several complications of either technical (self-reported fracture or loosening of the implant supported prosthesis) or biological (self-reported episode(s) of peri-implant inflammation) nature, and the proportion who experienced both types of complications. The proportion that reported no complications was 55.8%: 35.1% experienced either biological or technical complication(s) and 9.1% experienced both. Technical complication(s) were experienced by 28.3% and 24.2% of TLP and MTOR patients, while biological complication(s) were experienced by 33.9% and 23.5%, respectively. Significantly more complications were reported among TLP patients compared with MTOR patients when comparing combined complications ($p < .001$) and biological complications alone ($p < .001$).

3.3 | Factor analysis

The prerequisites for factor analysis were fulfilled, with several correlations above 0.30, a significant Bartlett's test and a KMO value of 0.918, which exceeded the recommended value of 0.60. The Kaiser criterion and the scree plot both suggested a three-factor solution, which was considered conceptually reasonable.

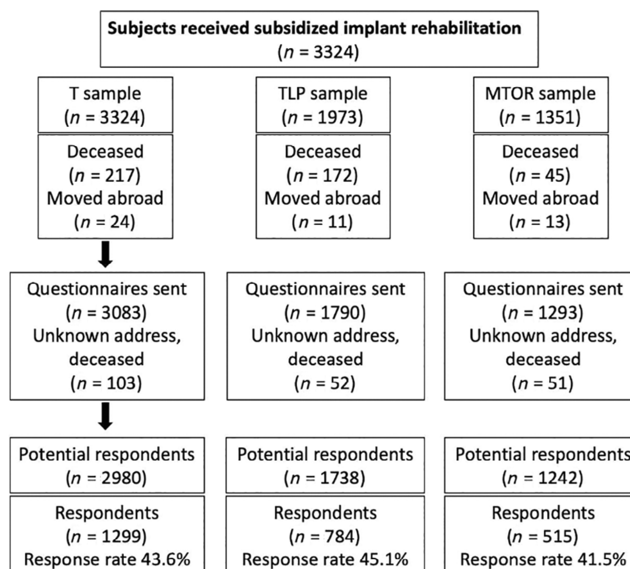

FIGURE 1 Flow-chart of the responses, reported for the total sample (T), for patients who suffered tooth loss following periodontitis (TLP) and for patients who missed teeth for other reasons (MTOR).

TABLE 1 Demographics of the respondents, reported for the total sample, for patients who suffered tooth loss following periodontitis and for patients who missed teeth for other reasons.

	Total population ($n = 1299$)	Tooth loss periodontitis ($n = 784$)	Missing teeth other reasons ($n = 515$)
Age			
Mean ± SD	64.4 ± 14.3	70.4 ± 9.0	55.4 ± 16.3
Median	68.0	71.0	56.0
Range	25–94	34–94	25–92
Sex (female, %)	50.7%	52.5%	47.8%
Nationality Norwegian (%)	95.9%	95.3%	97.3%
Higher education (university/college, %)	47.0%	38.0%	60.9%
Self-funded cost implant treatment (%)			
< €2000	33.2%	20.0%	52.9%
€2000–7000	45.0%	51.3%	37.9%
> €7000	20.1%	28.8%	9.2%
Extent of therapy, number of implants (%)			
1	32.8%	21.2%	50.2%
2–3	34.0%	36.2%	30.7%
4–5	17.6%	22.0%	11.0%
6 or more	15.1%	20.2%	7.6%
No remaining implant(s)	0.5%	0.4%	0.6%

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TABLE 2 Relative frequency distribution of questionnaire statements, reported for the total sample (T, $n = 1299$), patients who suffered tooth loss following periodontitis (TLP, $n = 784$) and patients who missed teeth for other reasons (MTOR, $n = 515$).

	Questionnaire items frequency distribution		Fully disagree	Partly disagree	Neither agree nor disagree	Partly agree	Fully agree	Missing	χ^2 test
Q1	I am satisfied with the treatment outcome	T	3.1%	2.1%	4.2%	20.6%	69.6%	0.4%	0.445
		TLP	2.8%	1.9%	4.8%	19.5%	70.4%	0.5%	
		MTOR	3.5%	2.3%	3.3%	22.2%	68.5%	0.2%	
Q2	I was happy with the aesthetic treatment outcome at delivery	T	1.2%	1.9%	4.6%	20.3%	71.7%	0.3%	0.117
		TLP	0.8%	1.4%	5.2%	19.9%	72.4%	0.3%	
		MTOR	1.8%	2.7%	3.7%	21.0%	70.4%	0.4%	
Q3	I am happy with the aesthetic treatment outcome now	T	2.6%	2.5%	6.1%	19.8%	68.0%	1.0%	0.073
		TLP	2.4%	1.9%	6.8%	18.2%	69.8%	0.9%	
		MTOR	2.9%	3.5%	4.9%	22.2%	65.4%	1.2%	
Q4	The implant treatment has improved my self-confidence	T	5.1%	2.6%	39.1%	19.5%	32.4%	1.3%	<0.001
		TLP	4.2%	2.6%	34.2%	20.8%	36.7%	1.5%	
		MTOR	6.4%	2.7%	46.5%	17.5%	25.9%	1.0%	
Q5	The implant treatment has improved my chewing ability	T	4.0%	2.3%	23.0%	23.1%	46.9%	0.7%	<0.001
		TLP	3.8%	1.9%	17.5%	23.0%	53.1%	0.8%	
		MTOR	4.3%	2.9%	31.3%	23.3%	37.5%	0.5%	
Q6	The implant treatment has made it easier for me to talk	T	13.2%	5.5%	46.7%	13.9%	19.3%	1.3%	<0.001
		TLP	11.1%	4.5%	44.8%	14.7%	23.6%	1.4%	
		MTOR	16.3%	7.2%	49.6%	12.8%	12.8%	1.2%	
Q7	The implant treatment has made it easier for me to smile	T	7.4%	4.1%	30.7%	19.2%	37.8%	0.8%	<0.001
		TLP	6.1%	2.9%	27.6%	20.3%	42.2%	0.9%	
		MTOR	9.3%	5.8%	35.4%	17.5%	31.1%	0.8%	
Q8	The implant treatment has made it easier for me to be social	T	11.2%	4.3%	42.0%	15.7%	25.3%	1.5%	<0.001
		TLP	9.1%	3.7%	39.5%	16.5%	29.7%	1.5%	
		MTOR	14.6%	5.3%	45.7%	14.6%	18.5%	1.4%	
Q9	It is easy for me to clean the implants	T	1.9%	4.2%	11.6%	31.2%	49.1%	1.9%	0.795
		TLP	2.0%	4.2%	11.0%	30.4%	50.3%	2.0%	
		MTOR	1.8%	4.1%	12.7%	32.4%	47.8%	1.4%	
Q10	The implant treatment has caused side-effects	T	65.9%	12.8%	8.5%	6.7%	4.9%	1.2%	0.513
		TLP	66.0%	12.7%	7.8%	6.8%	5.5%	1.3%	
		MTOR	66.1%	13.1%	9.8%	6.6%	3.9%	0.6%	
Q11	I was informed about treatment options before starting treatment	T	11.5%	8.1%	21.9%	21.3%	35.6%	1.5%	0.002
		TLP	11.1%	6.5%	20.3%	20.9%	39.5%	1.7%	
		MTOR	12.1%	10.5%	24.3%	22.0%	29.8%	1.4%	
Q12	I was informed about follow-up and maintenance care after the treatment	T	8.0%	7.6%	13.2%	23.6%	46.4%	1.2%	<0.001
		TLP	6.6%	5.4%	11.5%	23.2%	52.3%	1.0%	
		MTOR	10.1%	11.1%	15.8%	23.9%	37.5%	1.6%	
Q13	I got the right treatment for my dental problems	T	1.8%	1.2%	6.4%	17.4%	72.4%	0.8%	0.770
		TLP	1.9%	1.5%	6.5%	17.2%	71.8%	1.0%	
		MTOR	1.6%	0.8%	6.2%	17.5%	73.5%	0.4%	
Q14	My tooth-problems were solved by the treatment I underwent	T	2.2%	1.5%	5.3%	20.0%	70.0%	1.0%	0.383
		TLP	2.3%	1.4%	6.1%	19.1%	69.6%	1.3%	
		MTOR	1.9%	1.8%	3.9%	21.4%	70.6%	0.4%	
Q15	The implant treatment was worth the financial cost	T	5.3%	4.5%	12.6%	22.1%	55.0%	0.5%	0.015
		TLP	5.7%	5.4%	13.4%	23.6%	51.3%	0.6%	
		MTOR	4.7%	3.1%	11.5%	19.6%	60.7%	0.4%	

(Continues)

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TABLE 2 (Continued)

	Questionnaire items frequency distribution		Fully disagree	Partly disagree	Neither agree nor disagree	Partly agree	Fully agree	Missing	χ^2 test
Q16	I would undergo the same treatment again	T	4.4%	1.4%	7.5%	19.5%	66.1%	1.1%	0.124
		TLP	5.0%	1.8%	8.3%	19.8%	63.6%	1.5%	
		MTOR	3.5%	0.8%	6.4%	18.9%	70.0%	0.4%	
Q17	My expectations for the implant treatment were met	T	3.1%	2.8%	7.5%	20.6%	65.4%	0.5%	0.147
		TLP	3.4%	2.6%	8.7%	19.1%	65.7%	0.5%	
		MTOR	2.5%	3.3%	5.8%	22.8%	65.0%	0.4%	

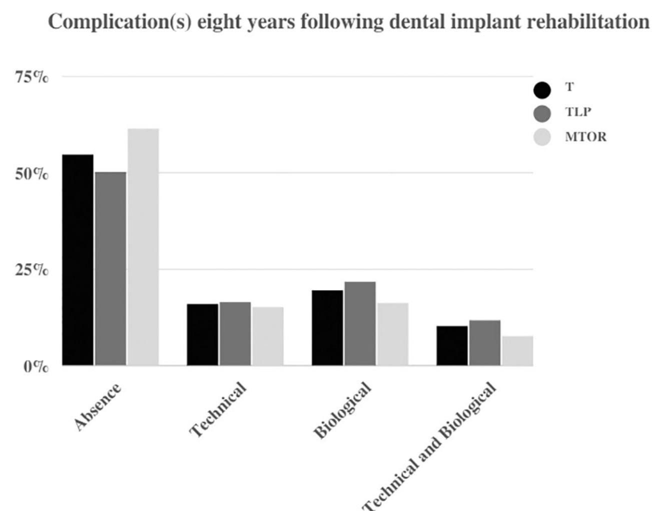

FIGURE 2 Proportion of patients who reported experience of complication(s), reported for the total sample (T), for patients who suffered tooth loss following periodontitis (TLP) and for patients who missed teeth for other reasons (MTOR).

This three-factor solution explained 68% of the variance in the PROs. Two questionnaire items, namely assessing cleansability of the implant-supported prosthesis and side effects, were discarded after the initial factor analysis. These items showed factor loadings below the chosen threshold of ≥0.50, and a conceptual evaluation indicated poor fit within the measurement model. Factor loadings, Cronbach's-α's and the variance explained for each factor are presented in Table 3. The three factors exposed by factor analysis were: *Patient satisfaction*, which included items assessing overall satisfaction (Q1), aesthetic outcome of the treatment (Q2, Q3), treatment justification (Q13, Q14), cost–benefit (Q15), intention to undergo the same treatment again if needed (Q16) and match between expectation and the perceived outcome (Q17); *oral function*, which included items assessing self-confidence (Q4), and whether chewing (Q5), talking (Q6) smiling (Q7) and being social (Q8) were easier following the treatment; and *pre-treatment information*, which included items assessing to which degree the patient received information on treatment alternatives (Q11) and on maintenance and follow-up care (Q12).

Sum scores and descriptive statistics for the three factors were calculated as follows:

Patient satisfaction: Mean 4.47, SD ±0.74, skewness −2.10, kurtosis 4.81.

Oral function: Mean 3.64 ± 0.96, skewness −0.48, kurtosis −0.14.

Pre-treatment information: 3.78 ± 1.13, skewness −0.75, kurtosis −0.21.

The condensed measures *patient satisfaction* and *oral function* were considered relevant as outcome variables in the regression analyses, whereas the condensed measure *pre-treatment information* was considered relevant as an independent variable.

3.4 | Regression analysis of *patient satisfaction*

The assumptions for multiple linear regression analysis were met. All variables had values within the range of chosen cut-offs for skewness and kurtosis, no multi-collinearities were found for the independent variables and residual distribution plots showed a normal distribution. No two-fold interactions were present among the variables selected by backward elimination.

Model analysis identified the following variables as predictors of *patient satisfaction* (Table 4); increasing age and *pre-treatment information* predicted higher patient satisfaction, while self-reported complications and higher self-funded cost predicted lower *patient satisfaction*. Rehabilitation following MTOR predicted superior *patient satisfaction*.

3.5 | Regression analysis of *oral function*

Also for this model, the assumptions for multiple linear regression were met as all variables had values within the range of chosen cut-offs for skewness and kurtosis, no multi-collinearities were found for the independent variables and residual distribution plots showed a normal distribution. No two-fold interactions were present among the independent variables.

Model analysis identified the following variables as predictors of *oral function* (Table 4); increased self-funded cost, increased extent of therapy and *pre-treatment information* all predicted increased *oral function* following the implant rehabilitation. Increasing age, higher

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TABLE 3 Exploratory factor analysis with factor loadings, Cronbach's-α and variance explained for the condensed factors.

	Questionnaire item	*Patient satisfaction*	*Oral function*	*Pre-treatment information*
Q1	I am satisfied with the treatment outcome	0.88		
Q2	I was happy with the aesthetic treatment outcome at delivery	0.72		
Q3	I am happy with the aesthetic treatment outcome now	0.86		
Q4	The implant treatment has improved my self-confidence		0.75	
Q5	The implant treatment has improved my chewing ability		0.65	
Q6	The implant treatment has made it easier for me to talk		0.88	
Q7	The implant treatment has made it easier for me to smile		0.87	
Q8	The implant treatment has made it easier for me to be social		0.92	
Q11	I was informed about treatment options before starting treatment			0.84
Q12	I was informed about follow-up and maintenance care after the treatment			0.77
Q13	I got the right treatment for my dental problems	0.76		
Q14	My tooth problems were solved by the treatment I underwent	0.72		
Q15	The implant treatment was worth the financial cost	0.69		
Q16	I would undergo the same treatment again	0.81		
Q17	My expectations for the implant treatment were met	0.86		
	Reliability (α)	.92	.88	.64
	Variance explained (R^2)	.42	.18	.08

TABLE 4 Multiple linear regression analysis for the dependent variables *patient satisfaction* and *oral function*, analysed for the total sample ($n = 1299$).

Dependent variable	β (95% CI)	*p*-Value
Patient satisfaction		
Age (years)	.037 (.013–.061)	.002
Self-funded cost	−.552 (−.996 to −.107)	.015
Technical complication(s)	−1.988 (−2.653 to −1.322)	<.001
Biological complication(s)	−.2.997 (−3.651 to −2.342)	<.001
Reason for missing teeth	−.990 (−1.698 to −.283)	.006
Pre-treatment information	1.003 (.873–1.133)	<.001
R^2	.304	
Oral function		
Age (years)	−.031 (−.054 to −.009)	.007
Self-funded cost	.658 (.207–1.109)	.004
Level of education	−1.080 (−1.365 to −.795)	<.001
Extent of therapy	.663 (.353–.974)	<.001
Technical complication(s)	−.618 (−1.236 to .000)	.050
Biological complication(s)	−.808 (−1.411 to −.204)	.009
Reason for missing teeth	.610 (−.042 to 1.262)	.067
Pre-treatment information	.470 (.350–.589)	<.001
R^2	.184	

Abbreviation: CI, confidence interval.

level of education and self-reported complications predicted lower *oral function*.

4 | DISCUSSION

In the present study, 90% of the patients reported full or partial satisfaction with the treatment outcome 8 years following dental implant therapy, irrespective of the reason for missing teeth. Patients in the TLP sample reported a significantly higher level of all questionnaire items included in *oral function*, namely improved self-confidence, masticatory function and the ability to smile, talk and be social. TLP patients were also better informed about treatment alternatives and post-operative care compared with MTOR patients. Complications were frequently reported in both samples, but significantly more often in the TLP sample. The presence of technical and biological complications predicted inferior *patient satisfaction* and *oral function*. The proportion of patients who reported full or partial satisfaction with the therapy, the aesthetic outcome at delivery and at 8 years later and an intention to undergo the same treatment again was high (85%–90%) in both samples.

The results from this investigation corroborate the findings from previous studies (Adler et al., 2016; Derks et al., 2015; Johannsen et al., 2012; Pjetursson et al., 2005; Simonis et al., 2010) confirming that most patients are fully or partly satisfied following implant rehabilitation. These results are of interest for clinicians, academics and health authorities.

PROs of dental implant rehabilitation have previously been suggested to be influenced by age, sex and extent of therapy (Derks et al., 2015). The present study supports increased age to predict higher *patient satisfaction*. Reporting of history of any complications strongly predicted lower patient satisfaction in the present sample.

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Derks et al. (2015) found increased extent of therapy to influence patient satisfaction. Importantly, that study did not include analysis of self-reported complications in the explanatory models. The present findings suggest that occurrence of complications, rather than solely the extent of treatment, constitutes a greater influence on *patient satisfaction* following implant rehabilitation. Adler et al. (2016) also reported that a history of complications reduces patient satisfaction following therapy. Sex was not a significant predictor of *patient satisfaction* in the present study. Previous studies (Adler et al., 2016; Baracat et al., 2011) also did not report sex differences with respect to PROs after implant rehabilitation.

The present results suggest that the reason for missing teeth affects PROs following dental implant rehabilitation. Previous reports did not consider the reason for missing teeth when evaluating PROs. TLP patients reported improved self-confidence, masticatory function, ability to smile and talk and being social when compared with the MTOR patients, and in the multivariable regression model a trend towards predicting greater *oral function* improvement was evident for TLP patients. This finding may imply a more severe oral disability prior to treatment. It is well documented that periodontitis reduces oral-health-related quality of life (Durham et al., 2013; Fuller et al., 2020) and that the impairment is related to the stage and grade of periodontitis (Goergen et al., 2021). All patients in the TLP sample had, according to the criteria for reimbursement, lost teeth to periodontitis, which assigned them to a stage III/IV periodontitis diagnosis, indicating severe periodontitis. TLP patients were also better informed of the treatment alternatives and follow-up care. Given the difference in the extent of therapy and reason for missing teeth, as well as the recognition of periodontitis as a risk factor of peri-implantitis, this finding may be expected. *Pre-treatment information* was identified as a strong predictor of both *patient satisfaction* and also *oral function*. This finding is particularly interesting for clinicians and emphasizes the importance of patient education and pre-treatment information for success in dental implant therapy.

In the present study sample, 55.8% of the respondents reported absence of complications 8 years following treatment. A previous investigation from a Swedish specialist clinic found 64.5% of patients without complications 8 years following treatment (Adler et al., 2020), while a meta-analysis from longitudinal samples found 33.6% of patients with dental implants to experience complications in a 5-year observation period (Pjetursson et al., 2012). The patients in the present study sample were treated in all types of clinical settings in Norway, in contrast to Adler et al. (2020) and Pjetursson et al. (2012) who both evaluated patients in university- and clinic-specific cohorts. Despite these differences, the figures compare well with these previous reports.

The response rate in the current study is considerably lower than that in two comparable studies performed in Sweden, both of which reached response rates of about 80% (Adler et al., 2016; Derks et al., 2015), but compares well with those of other surveys from Norway (Simensen et al., 2015), Australia (Layton & Walton, 2011) and Sweden (Johannsen et al., 2012), with response rates of 47%, 50% and 61%, respectively. The present study included patients from a national register of recipients of financial support for dental implant therapy in 2014. This differs from most previous investigations, which have mainly investigated cohorts from clinics or universities. Further, all age groups were included, which is in contrast to the study by Derks et al. (2015), who evaluated certain age categories. It should also be noted that the period since treatment is longer than in Derks et al. (2015), which investigated satisfaction 6 years following therapy. The questionnaire used in the present study was more comprehensive, increasing the respondent burden, which may in turn have affected the response rate. To fulfil the requirements for NNIS subsidy of implant rehabilitation, specific clinical conditions must be met. This system is trust-based, but with consequences for the clinician if misused, and case documentation is required. Therefore, in this study it is assumed that clinicians comply diligently with the purpose of the NNIS. However, the diagnostic prerequisites will always be based on clinical judgement. When and why a tooth is lost, whether it is due to periodontitis or other reasons, may be a matter of opinion and personal judgement and something clinicians consider differently according to their training and experience (Lang-Hua et al., 2013, 2014). It is inevitable that the large number of dentists involved in the treatment of the 1299 respondents have different considerations of when a tooth is lost as a result of periodontitis.

The multivariable regression models aimed to identify predictors of *patient satisfaction* and *oral function*. Model analysis revealed an R^2 of .304 and .184, respectively, indicating a clear difference in explained variance between the models. Explanatory models aiming at describing subjective phenomena such as reporting of satisfaction and function following a treatment will in general have a lower expected explained variance (Cohen, 2013). Although the explained variance may be considered limited, the present results provide new insights into factors predicting PROs. It should be clearly noted that the models do not include all variables that may influence the outcomes and should therefore be interpreted carefully.

This study is based on patient-reported data. It has been suggested that oral-health-related variables such as the number of teeth may be self-reported with fair precision (Buhlin et al., 2002), but whether the same applies to dental implants remains to be explored. The lack of information on other oral health variables and prosthesis type is also a limitation of the present study. A detailed description of oral health status and type of prosthesis will be performed for a subsample of patients who will attend a clinical examination at a later stage of this research.

Although all patients had undergone dental implant rehabilitation, some might have received implants before and/or after 2014 as well. Consequently, it is likely that the response reflects their dental implant rehabilitation in general, and not in particular that from 2014. Life expectancy in the included 11 counties is similar to that of the remaining counties (Knudsen et al., 2019), indicating representativeness of the general Norwegian population. Although the respondents are representative of the total sample in terms of mean age and sex distribution, one cannot rule out response bias in survey research.

The questionnaire items were designed to enable nuanced feedback from the respondents, with response alternatives ranging from

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fully disagree to fully agree. Yet, one should note that the replies to some items measuring oral function may have alternative interpretations. For example, a disagreement to the statement "The implant treatment has improved my self-confidence" may imply worsened self-confidence, but it may also indicate that self-confidence was always high irrespective of the implant rehabilitation.

In conclusion, this study demonstrated that approximately 90% of patients who received implant rehabilitation in Norway in 2014 were partly or fully satisfied with the overall treatment outcome and aesthetic outcome, irrespective of the reason for missing teeth. Patients who suffered tooth loss due to periodontitis were better informed about treatment alternatives and follow-up care compared with those who missed teeth for other reasons. Report of complications and lack of pre-treatment information predicted inferior *patient satisfaction* and *oral function*. These findings should be further evaluated and confirmed in other populations.

AUTHOR CONTRIBUTIONS

Erik Klepsland Mauland and Anders Verket contributed to study design, data acquisition, analysis, interpretation and manuscript drafting. Vibeke Hervik Bull and Elisabeth Lind Melbye contributed to study design, analysis, interpretation and manuscript drafting. All authors gave their final approval of the version to be published.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest related to the study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

The study protocol was approved by the regional ethics committee (REK 137258/2020) and Norwegian Centre for Research Data. Returning the questionnaire was voluntary.

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