Imact of implant prosthetic therapy on oral health-related quality of life

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IMPACT OF IMPLANT PROSTHETIC THERAPY ON ORAL HEALTH-RELATED QUALITY OF LIFE

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Some time ago, I got drawn into the beautiful world of scientific literature reviews. I want to thank the Italian research group from whom and along with whom I have learned oh-so-much.

Filippo, Stefano, Rossana, and Maria Chiara, grazie mille!

Summary

IMPACT OF IMPLANT PROSTHETIC THERAPY ON ORAL HEALTH-RELATED QUALITY OF LIFE

The clinical outcomes of implant therapy are well documented in the scientific literature. Data and clinical knowledge on outcomes such as implant and prosthetic suprastructure survival, marginal bone loss, mechanical, technical and biological complications and aesthetics serve clinicians as evidence-based guidance for clinical treatment planning. These outcomes are, however, intangible to the patient's mind. To assess patients' subjective evaluations of the treatment and treatment-related variables, patient-reported outcome measures were introduced in research. Oral health-related quality of life (OHRQoL) is one of the patient-reported outcome measures.

Data supports that tooth loss has a profoundly negative impact on an individual's quality of life, affecting function, psychosocial well-being and aesthetics. This narrative review focuses on answering the question of whether oral rehabilitation with dental implants in edentulous individuals improves their oral health-related quality of life.

Published data confirms that oral rehabilitation with dental implants, indeed, significantly improves oral health-related quality of life. However, certain treatment modalities of complete and partial edentulism and their outcomes are not equally well-represented in the literature. Furthermore, strong conclusions on the superiority of the performance of implant treatment modalities compared to conventional prosthodontic treatment modalities cannot always be drawn.

Keywords: oral health-related quality of life, patient-reported outcome measures, oral rehabilitation; dental implants; implant-prosthodontic treatment

Sažetak

UTJECAJ IMPLANTOPROTETSKE TERAPIJE NA KVALITETU ŽIVOTA POVEZANU S ORALNIM ZDRAVLJEM

Klinički ishodi implantološke terapije dobro su dokumentirani u znanstvenoj literaturi. Poznavanje podataka o ishodima kao što su preživljavanje implantata i protetske suprastrukture, gubitak marginalne kosti, mehaničke, tehničke i biološke komplikacije i estetski ishodi služe kliničarima kao smjernice utemeljene na dokazima za planiranje kliničkog liječenja. Ti su ishodi, međutim, neopipljivi za pacijentov um. Kako bi se procijenila subjektivna shvaćanja pacijenata o liječenju i varijablama povezanima s liječenjem, u znanstvena istraživanja uvedene su tzv. mjere ishoda koje navodi pacijent (engl. *patient-reported outcome measures)*. Kvaliteta života povezana s oralnim zdravljem jedna je od mjera ishoda koje navodi pacijent.

Podaci iz znanstvene literature potvrđuju da gubitak zubi ima značajan negativni utjecaj na kvalitetu života pojedinca te utječe na njegovu funkciju, psihosocijalnu dobrobit i estetiku. Cilj ovo narativnog literaturnog pregleda jest dati odgovor na pitanje poboljšava li oralna rehabilitacija dentalnim implantatima u bezubih osoba njihovu kvalitetu života povezanu s oralnim zdravljem.

Dostupni literaturni podaci potvrđuju da oralna rehabilitacija dentalnim implantatima, doista, značajno poboljšava kvalitetu života povezanu s oralnim zdravljem. Međutim, određeni modaliteti liječenja potpune i djelomične bezubosti i njihovi ishodi nisu jednako dobro zastupljeni u znanstvenoj literaturi. Nadalje, ne mogu se donijeti snažni zaključci o superiornosti ishoda pojedinih modaliteta liječenja dentalnim implantatima u usporedbi s konvencionalnim modalitetima protetskog liječenja.

Ključne riječi: kvaliteta života povezana s oralnim zdravljem; mjere ishoda koje navodi pacijent; oralna rehabilitacija; dentalni implantati; implantoprotetska terapija

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LIST OF ABBREVIATIONS

WHO	World Health Organization
PBO	Patient-Based Outcome
PRO	Patient-Reported Outcome
PROM	Patient-Reported Outcome Measure
VAS	Visual Analogue Scale
QoL	Quality of Life
OHRQoL	Oral Health-Related Quality of Life
GBD	Global Burden of Disease Study
OHIP	Oral Health Impact Profile
OIDP	Oral Impact on Daily Performance
GOHAI	General/Geriatric Oral Health Assessment Index
DIDL	Dental Impact on Daily Living
OHRQoL-UK	Oral Health-Related Quality of Life measure United Kingdom
SIQ	Social impact Questionnaire
GSS	General Satisfaction Score
GHQ	General Health Questionnaire
EORTC QLQ-C30	European Organization for Research and Treatment of Cancer Quality of Life Questionnaires – Cancer Patients
EORTC QLQ-H&N35	European Organization for Research and Treatment of Cancer Quality of Life Questionnaires – Head & Neck
SF	Short Form
EPIQ	Edentulous Patient Impact Questionnaire

CD	Complete denture
RPD	Removable partial denture
IOD	Implant-supported/retained overdenture
IFCD	Implant-supported fixed complete denture
FPD	Fixed partial denture (tooth supported)
IFPD	Implant-supported fixed partial denture
RCT	Randomised controlled trial

1. INTRODUCTION

Dental implant therapy has become part of the daily clinical routine in dental medicine. Implant placement and restoration of single or multiple edentulous sites are nowadays procedures nonexclusive to specialists in oral surgery or periodontology and are well integrated into the general dental practice (1). In the 50 years since Per-Ingvar Brånemark first introduced the concept of osseointegration (2), the popularity of dental implants has grown significantly as an alternative to the conventional prosthodontic treatment of edentulous areas with dentures and bridges.

Clear and accurate information on the number of placed dental implants and its dynamics over time is still lacking. A narrative review from 2014 on trends in the use of dental implants estimates that 100.000 – 450.000 dental implants are placed annually, which is comparable to the number of placed hip and knee implants (3). In 2016, Elani et al. were among the first to publish data on trends in the use of dental implants, assessing data from the seventh US NHANES (National Health and Nutrition Examination Surveys) study (4). The authors estimated that the number of Americans with dental implants increased from 0.7% in 1999 to 5.7% in 2016. They estimated that by 2026 that percentage could rise to 23%. In Europe, especially in developed countries, this number could be significantly higher, as the annual report (2017) of one of the world's largest implant companies emphasises that the number of implants per 10,000 inhabitants in the US is only half as high as in Europe's largest market (5).

The short-, mid- and long-term clinical outcomes of implant therapy, such as implant and prosthetic suprastructure survival, marginal bone loss, mechanical, technical and biological complications and aesthetics, are all well documented in the scientific literature. Subjective, patient-related outcomes (PROMs) have gained considerable interest in medical research decades ago. Their introduction in dental medicine research came in delay, and so did in its specific disciplines, such as implant dentistry. Some of the reported outcomes of patients include subjective perceptions of their condition and well-being, satisfaction with the treatment outcome and received care, their adherence to treatment, adverse effects of treatment and other non-clinical assessments. Health- and oral health-related quality of life are also PROMs (6).

This narrative review aims to present data on the impact of implant-prosthodontic treatment on the oral health-related quality of life of individuals with complete and partial edentulism. It aims to give a broad perspective on the topic, providing a qualitative data summary. It mostly

synthesises data from randomised control trials (RCTs) and prospective cohort studies to capture the effect of treatment in edentulous individuals. Conventional prosthodontic treatment modalities are not the focus of this review, however, the data on their impact will be presented in the scope of studies comparing them to implant-prosthodontic treatment.

2. LITERATURE REVIEW

2.1. Health

2.1.1. Definition of health

To understand the impact health, and more precisely, oral health, has on an individual's quality of life, it is essential first to define health.

From a (patho)physiological standpoint, health can be defined as bodily systems and processes that run and function normally. This "normality" can be assessed through widely acknowledged measures. An example of it would be a healthy blood pressure of 120/80 mm Hg. However, there are no single, universal measures of health, and in fact, our perception and acknowledgement of what is health vary in different subpopulations, e.g. women vs men, adolescents vs elderly, etc.

The opposite of health is a disease. Thus, another definition of health, stemming from a biomedical model, is that health is an absence of the disease. Unfortunately, the biomedical, scientific, disease-oriented model of health is still mainly presented in Western societies.

In 2008 Naidoo and Wills defined health through its many dimensions, in particular physical health, mental health, emotional health, social health, spiritual health, sexual health, societal health, and environmental health. Therefore, their definition of health is seen as a holistic concept (7).

The most widely cited definition of health in the literature is that of the World Health Organization (WHO) - "a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity" (Figure 1) (8).

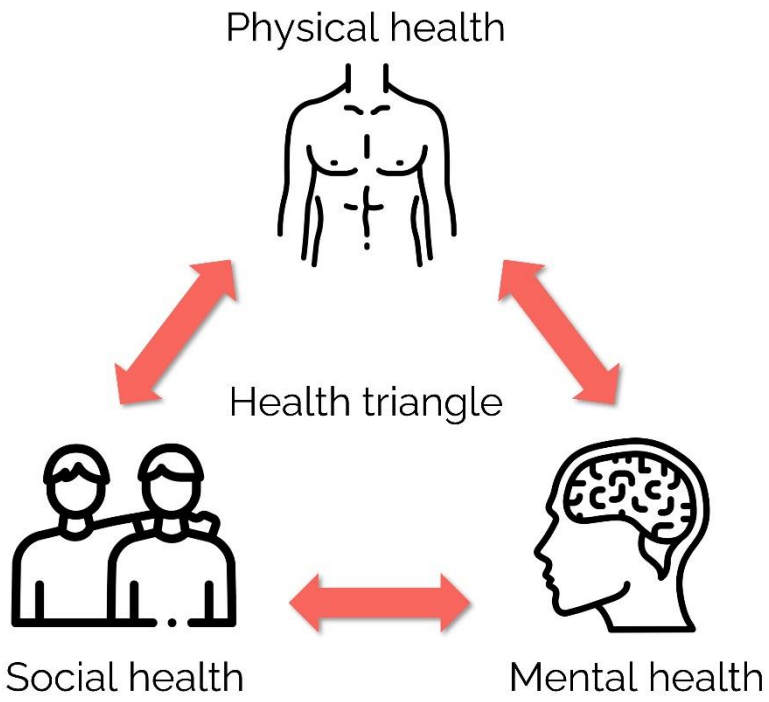

Figure 1. The health triangle encompasses three aspects of health.

Originally, this definition was given in 1948 and has been heavily criticised for not being inclusive of other health dimensions. Later, in 1984, it was revisited, and a more multidimensional view was adopted (Table 1).

Table 1. WHO definitions of health (8)

WHO definition of health 1948	WHO definition of health 1984
„Health is a complete state of physical, mental and social well-being and not merely the absence of disease or infirmity."	„Health is the extent to which an individual or group are able, on the one hand, to realize aspirations and satisfy needs; and on the other hand, to change or cope with the environment."

2.1.2. Definition of oral health

How does one define oral health? If following the biomedical model and seeing oral health as the absence of oral disease, then one could assume oral health presumes the presence of full, aligned dentition with the absence of any hard or soft tissue conditions. Despite the fact that oral health is an indivisible component of general health, up until recently, there was no clear, universally accepted definition of it. In 2016, the World Dental Federation (French: Fédération Dentaire Internationale. FDI) approved a new definition of oral health, acknowledging the multidimensionality and attributes of oral health (Table 2) (9,10).

Table 2. Definition of oral health according to the FDI (2016) (9)

Definition of oral health: Oral health is multifaceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and disease of the craniofacial complex.
Further attributes of oral health: — It is a fundamental component of health and physical and mental well-being. It exists along a continuum influenced by the values and attitudes of people and communities. — It reflects the physiological, social, and psychological attributes that are essential to the quality of life. — It is influenced by the person's changing experiences, perceptions, expectations, and ability to adapt to circumstances.

2.2. Patient-reported outcomes and patient-reported outcome measures

In medicine and dental medicine, the state and continuous monitoring of physical health and disease and the impact of treatments are evaluated and measured through various clinical indicators (measures/biomarkers) that provide objective information to the medical/dental

professional. Their utility is not only clinical but also scientific, as they are used in research. For example, a periodontist will use a variety of clinical indicators such as periodontal pocket probing depth (PPD), gingival recession (REC), plaque index (PI) or bleeding on probing (BOP) to diagnose a patient, plan and conduct a treatment accordingly, evaluate the outcomes of the treatment and monitor the patient enrolled in the supportive care. To a researcher, a decay-missing-filled teeth (DMTF) index will provide information on the caries prevalence and treatment needs in a particular population. While indispensable for the professionals, these indicators are intangible to the patient. Thus, the need for the assessment/measurement of patient-based outcomes, also known as patient-reported outcomes (PROs), emerged. In the early literature of the 1990s (11), the terms patient-based outcomes (PBOs) and patient-based outcome measures were also used and can be still found today.

What differentiates clinical (objective) indicators and PROs is that the latter are the patient's direct, subjective report on various outcomes. Data acquired from patients may include information in the domain of (i) behaviours (e.g. sugar intake, smoking, brushing frequency), (ii) symptoms (e.g. pain, chewing difficulty, discomfort) and (iii) health-related quality of life (e.g. inability to enjoy a dinner outside because the loss of teeth creates difficulties in chewing a steak). As such, they complement the clinical measures. In fact, the history of PROs dates from the pharmaceutical industry, the development of drugs, and the incorporation of patient-provided information on the administered treatment (12). To provide an example, one may assess a clinical scenario in which a patient is administered a novel treatment. While clinical indicators may show benefits of the treatment (i.e. decrease in disease parameters), the patient may report a tremendous negative impact on their daily life (i.e. increased sleepiness, leading to work productivity impairment). This may, in turn, impact the patient's long-term compliance and drug intake, thus affecting the treatment outcome in an alternative way.

Patient-reported outcome measures (PROMs), as the name itself implies, are a measurement of a particular PRO (13). These measures include different tools (instruments) in the form of surveys and questionnaires (Figure 2).

Each measure consists of so-called items, which can be statements or questions. The item responses can be either categorical or continuous. Categorical variables are further defined as nominal (variables whose categories cannot be ranked), dichotomous (two mutually exclusive categories, e.g. yes/no, female/male) or ordinal (two or more categories that can be ranked, e.g. minimal/moderate/severe/unbearable pain). The Likert scale, named after the

psychologist Rensis Likert, is a psychometric scale, usually a 5-point scale (strongly agree / agree / neutral / disagree / strongly disagree), that captures the intensity of a respondent's feeling about a certain statement/question (14). While it is regarded as an ordinal scale as it has five categories that are ranked, researchers sometimes treat it as continuous, in particular, an ordinal approximation of a continuous variable (15). Visual Analogue Scale (VAS) found its application in medicine after initially being used in social sciences. Respondents mark a certain distance on a, now commonly, 100mm scale representing a continuum of a variable (e.g. pain).

Some of the reported outcomes of patients include subjective perceptions of their condition and well-being, satisfaction with the treatment outcome and received care, adherence to and adverse effects of treatment, and other non-clinical assessments. Finally, health- and oral health-related quality of life (OHRQoL) are also PROMs (6). OHRQoL will be discussed in further detail later in the text.

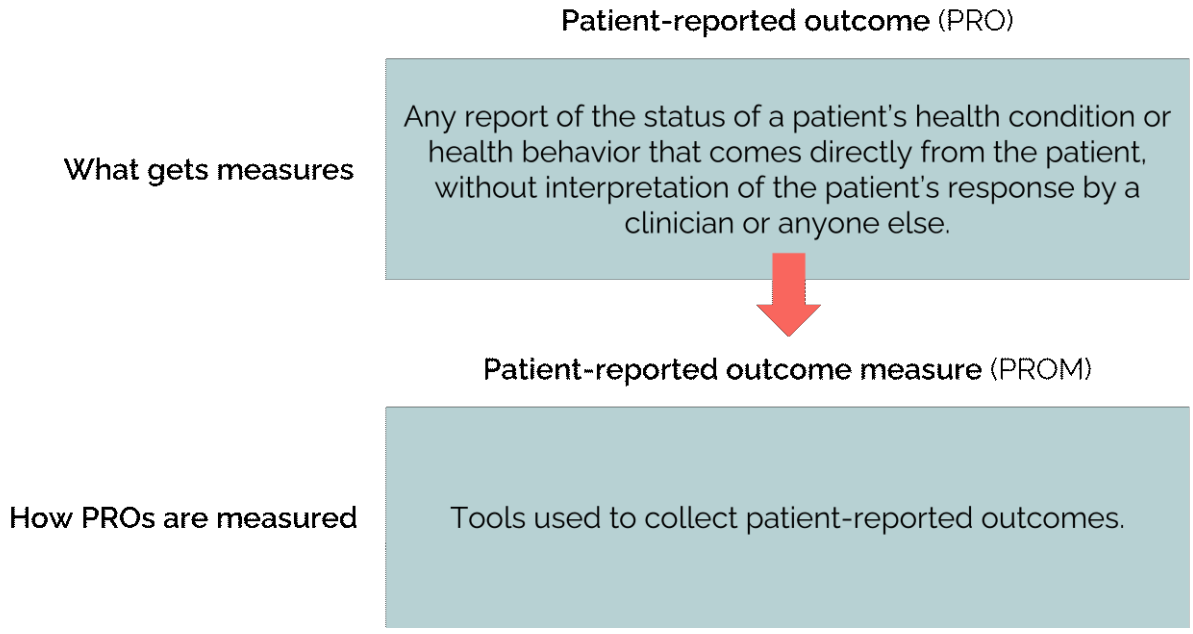

Figure 2. Relationship between PROs and PROMs

2.3. Oral health-related quality of life

In 1988 David Locker, a pioneering researcher in the field, proposed a new conceptual model of oral health. It aimed at measuring health status and, in particular, the impact of dental and oral diseases and conditions (i.e. impact on an individual's dietary choices) (16). In this model, Locker defined five domains that may be affected by oral diseases and conditions: impairment, functional limitation, discomfort, disability and handicap (Figure 3). Locker's model presented as the theoretical core for developing a patient-reported outcome measure known as oral health-related quality of life (OHRQoL).

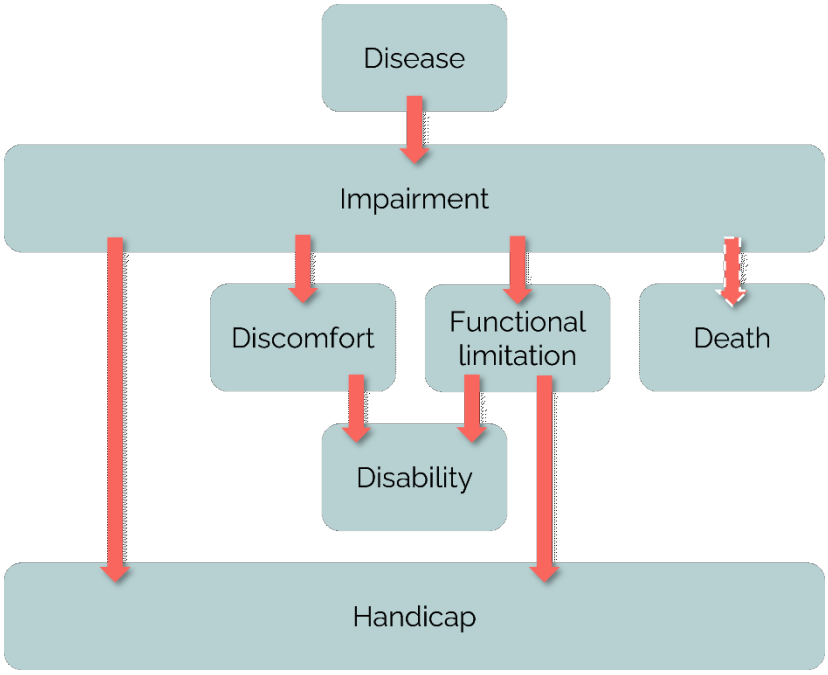

Figure 3. Locker's conceptual model of oral health.

The definition of OHRQoL is somewhat elusive, and there is no consensus on it. Health, disease and OHRQoL are different concepts. In fact, OHRQoL encompasses the extent to which oral diseases impact individuals' functioning and psychological being, including the symptoms derived from their oral conditions and diseases (17).

2.3.1. OHRQoL measures

As discussed before, OHRQoL measures are questionnaires in their essence, like other PROMs. OHRQoL measures can be generic or specific. A generic measure can be used to asses the impact of any oral disease or condition on quality of life. As an example, OHIP-14 can be used to assess both the impact of caries and periodontal disease on quality of life. On the other hand, specific measures are developed either for a particular population (children, i.e. Child-OIDP) or a condition (halitosis, i.e. Halitosis-Associated Life Quality Test, HALT or mandibular impairment, i.e. Mandibular Functional Impairment Questionnaire, MFIQ).

OHRQoL measures vary in their design (number of items/questions), focus on different domains and investigated areas, assessed populations and even countries. For example, the oral health-related quality of life (OHQOL) measure, developed by Kressin (18), assesses only three items, and its brevity is considered both strength, as it can be easily included in population surveys, and a weakness as it does not give a detailed insight in the impact of oral conditions on QoL. Conversely, Oral Health Impact Profile-49 (OHIP-49), while one of the most widely used instruments, led to the development of Oral Health Impact Profile-14 (OHIP-14), a more concise instrument that has been tested and validated and is widely used today. Oral Impact on Daily Performance (OIDP), developed by Adulyanon and Sheiham, was later modified by Gherunpong and coworkers in 2004 for the children population (Child-OIDP) (19). McGrath and Bedi have developed a specific questionnaire addressing the impact of oral conditions on quality of life in the population of United Kingdon individuals (20), as it is known that subjective perceptions of health and diseases and their impact are also influenced by cultural background. Its use, however, has since then not been limited to the United Kingdom only.

Some of the widely used measures in the fields of periodontology and implant dentistry are reported in Table 3.

OHRQoL measures are not only used to assess how oral conditions affect one's quality of life in the research setting but are also resourceful in understanding the outcomes of clinical procedures. While due to its complex theoretical background, clinicians may not appreciate its importance, OHRQoL is nowadays used more widely as the best practice information and may inform their clinical judgement and choice of procedures.

Table 3. Most frequently used OHRQoL measures in dental research.

OHRQoL measure	Authors, year	Assessed dimensions/items
General (Geriatric) Oral Health Assessment Index (GOHAI)	Atchison & Dolan, 1990 (21)	Assessing 3 domains: physical function, pain/discomfort, psychosocial impact. 12 items in total.
Oral Health Impact Profile (OHIP)	Slade & Spencer, 1994 (22)	7 domains: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap
Dental Impact on Daily Living (DIDL)	Leao and Sheiham, 1994 (23)	Assessing 5 dimensions of quality of life: comfort, appearance, pain, performance and eating restrictions. 36 items in total.
Oral Impact on Daily Performance (OIDP)	Adulyanon and Sheiham, 1997 (24)	Assessing frequency and severity of the impacts of oral conditions on 9 different groups of everyday activities: eating, speaking, toothbrushing, going out, smiling and showing teeth, emotional instability, carrying out major work or undertaking an important role and enjoying social contact.
Oral Health-Related Quality of Life-UK (OHQoL-UK)	McGrath & Bedi, 2001 (20)	Assessing 16 items: comfort, breath odour, general health, eating, appearance, speech, relax or sleeping, smiling or laughing, confidence, mood, care-free manner, personality, work, social life, finances, romantic relationship.

2.4. Tooth loss

In 1990 the World Bank originally warranted the Global Burden of Disease (GBD) Study. It was intended to serve as a source of information regarding the health of the populations worldwide to different stakeholders and policymakers. Since then, the GBD has collected and analysed hundreds of causes of death, disability, diseases, injuries and risk factors in 195 countries (21). After the first report, updates were subsequently published in the years 2010, 2013, 2015, 2016, 2017 and 2019.

For the professionals in the field of dental medicine, the GBD study became of great significance when in 2013, the burden of oral diseases was estimated for the first time. Marcenes et al. reported on the global burden of untreated caries, severe periodontitis and edentulism (22). The latest report, presenting data from the 2017 GBD Study, informed that 267 million people worldwide (95% UI, 235 to 300 million) had total tooth loss (defined as complete loss of natural teeth), and the burden was correlating negatively with the indicators of economic development (23).

When untreated, caries and periodontitis result in tooth loss (24). As reported in the literature, other risk indicators for tooth loss include older age, presence of visible dental plaque (25), previous tooth loss, and seeking dental treatment prompted by pain (26). When not treated, tooth loss results in significant aesthetic, functional, and psychological impairments (27). Functional impairments presume a decrease in chewing ability, diet changes, and speech difficulties (28). As previously reported in the literature, patients may favour aesthetics more than function and are more likely to seek treatment following the loss of anterior teeth compared to posterior (29). Reduction in vertical height and subsequent change in the appearance of the face's shape because of posterior tooth loss or complete edentulism has also been cited as a cause of aesthetic and emotional disturbances in individuals (30). Finally, the impairments mentioned above arising from tooth loss can impact the individual's quality of life, observed and measured through indices of OHRQoL (31).

However, the negative effects of tooth loss surpass the confinement of the oral cavity. Cognitive function, evaluated through Mini-Mental State Examination, is independently associated with the number of remaining teeth (32,33) and the number of functional tooth units, i.e. posterior occluding pairs (34). In fact, restoring missing teeth is associated with better cognitive function in the elderly (35,36). Frailty, defined as an ageing-related syndrome

of physiological decline (37,38), also seems to be associated with a lower number of remaining teeth (39–41).

Tooth retention has been recognised as an issue of public health importance. As a part of a national health promotion framework, "Health Japan 21", initiated in Japan in 2001, also suggested preserving teeth in the elderly, aiming to retain at least 20 teeth by 80 years of age.

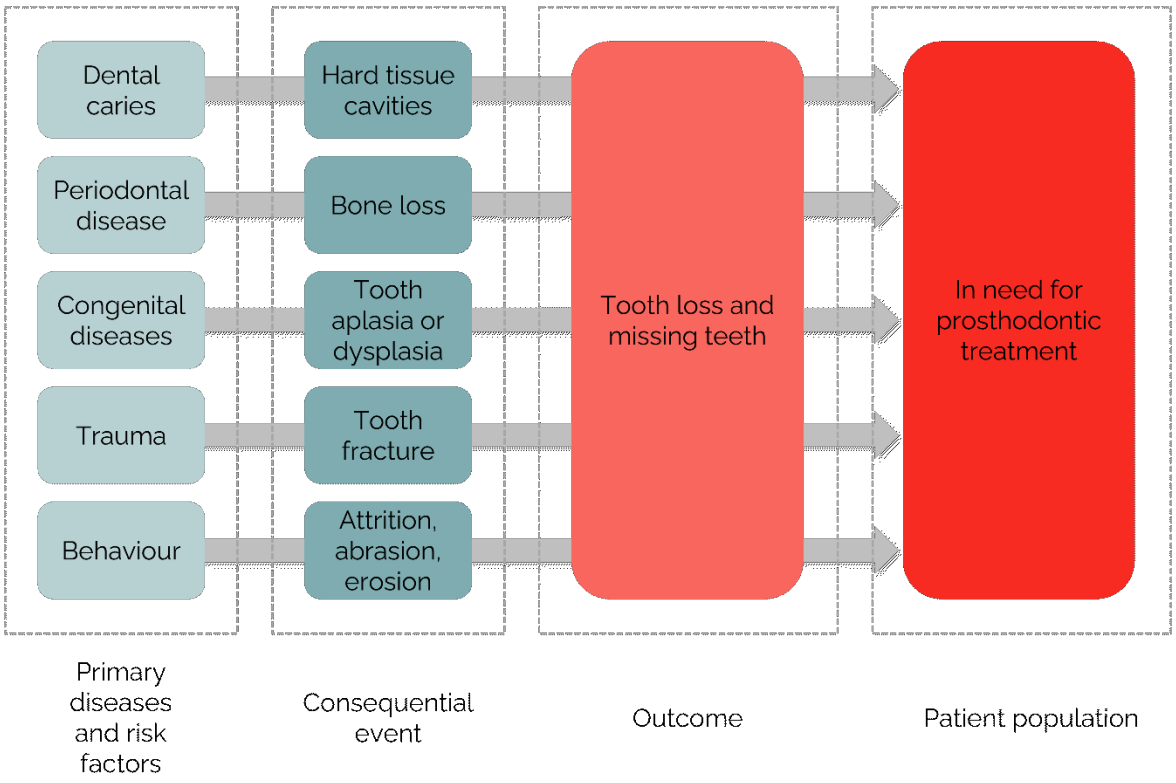

Figure 4. Impact of common oral diseases and risk factors.

2.4.1. Impact of tooth loss on quality of life

As discussed before, tooth loss leads to impairment of oral functions. It, thus, comes as no surprise that tooth loss also affects OHRQoL. The 2010 systematic review and meta-analysis by Gerritsen et al. concludes that tooth loss is, in fact, strongly associated with impaired OHRQoL (42). All studies included in the systematic review and meta-analysis reported the deteriorated OHRQoL because of tooth loss, irrespective of the study location (cultural

background) or the OHRQoL measure (questionnaire) used in the original study. Furthermore, the location of lost teeth and the distribution of edentulous areas were shown to be affecting the severity of the OHRQoL impairment. In particular, the highest negative impact on OHRQoL was reported in cases of anterior tooth loss and the number of occluding pairs, with a sharp increase once less than 20 teeth are present. While the former affects aesthetics, emotional, and psychosocial well-being, the latter can significantly contribute to functional disability.

Mack et al. compared the impact of tooth loss and prosthodontic replacement on QoL with the effects of different diseases on QoL. A large population study that included 1406 subjects from the SHIP study (Study of Health in Pomerania), where the impact of tooth loss on quality of life was assessed with a general health questionnaire, Short Form-12 (SF-12), concluded that reduced dentition (less or equal to 9 teeth) or the absence of prosthodontic tooth replacement, affects the physical index of quality of life. Moreover, this reduction was comparable to the one of renal or malignant disease (43).

In 2021 a group of authors expressed for the first time the impact of different oral conditions on OHRQoL, in particular oral function impact, employing normalised metric information (44). Partial edentulism and complete edentulism scored a mean of 1.6 and 2.6, respectively, on a 0 to 8 unit metric. However, the authors highlighted that the score ranged from 0 to 7.9 units in a sample of 154 subjects included in this systematic review.

2.4.2. Prosthodontic treatment for tooth loss

The periodontium, the tooth's supportive system, is crucial for the distribution and resorption of masticatory forces. When in function like chewing, teeth are intermittently loaded, which leads to reactive changes in the alveolar bone (45,46). Moreover, alveolar remodelling occurs throughout one's lifetime, in line with the dynamic changes in the dentition (47). Tooth extraction, irrespective of its causative factors (caries, periodontitis, root fracture, orthodontic treatment), is followed by changes in both hard- and soft tissues. The pivotal studies on changes occurring following tooth extraction by Schropp et al. (48), Cardaropoli et al. (49), and Araujo and Lindhe (50) showed that there is a substantial reduction of the alveolar ridge in the buccal-lingual plane and limited reduction in the apical-coronal plane. It can be expected that up to 50% of the original mass of the alveolar ridge is lost. The bone loss is

most significant in the buccal areas and the molar region. These changes are most substantial in the first three months; however, the remodelling of the post-extraction site can be expected up to one year following the event (48,51).

Treatment options for edentulism are various. Progressive residual ridge resorption in conventional complete and partial mobile denture wearers and tooth-supported fixed partial dentures (bridges) is inevitable. In long-term denture wearers, this may lead to functional and aesthetic impairment. Functional problems include a stability decrease and an increase in mobility of the denture, affected bite force, and difficulties with chewing, speaking, and producing certain sounds. Lower denture stability is particularly affected. Continuous alveolar ridge and jaw bone resorption also decrease the occlusal vertical dimension, inflicting facial aesthetics (52–55).

Dental implants were initially used for struggling conventional denture wearing patients. Today they are provided to both partially and completely edentulous patients for mobile and fixed prosthodontic appliances. They are associated with an initially higher cost of treatment, higher patient morbidity due to the surgical procedure involved, and, depending on the treatment protocol, sometimes a more extended period before the patient receives the final prosthodontic appliance.

2.4.3. Dental implant treatment

In medicine, implants are defined as any inert device or material inserted into tissue to repair or replace a missing part of the body. Insertion of "devices" to replace missing teeth stems back to the Mayan civilisation that used seashells as a replacement for mandibular teeth. In the 1910s, Greenfield started a long period of attempts to implant inserts of various shapes and building materials with lesser and greater success. However, the swift development of modern dental implantology commenced with Per Ingvar Brånemark's accidental discovery of osseointegration, a term he proposed, on an animal model, which he later implemented into dentistry (56).

Events following implant placement in a prepared bony bed were highlighted by Berglundh et al. (57) and Abrahamsson et al. (58) in 2003 and 2004, respectively, in an animal model. The implant's surface directly contacts the mature bone and bone marrow at the end of the healing

process. An osseointegrated implant is rigid, and there is no movement between the implant and the bone when subjected to (nonpathological) external forces. The process of the physiological bone remodelling continues permanently as a response to stress and mechanical loading.

Besides general health factors, various objectively "measurable" dental variables define prosthodontic treatment planning. Oral health status, in particular, the number of present teeth and their position, are taken into consideration when deciding on the type of prosthodontic treatment (59,60). Patient-reported outcomes, however, are or at least should be a significant contributing factor in the clinical decision-making process. Patient preferences, perception and satisfaction with treatment are PROs to which many clinicians are accustomed, even if they do not know them by their umbrella term. Today, the knowledge of the expected improvement of OHRQoL following different prosthodontic treatment modalities is becoming highly relevant.

2.5. Implant-prosthetic therapy of complete edentulism and OHRQoL

Conventional complete dentures (CDs) are supported by the residual bony ridge and alveolar mucosa for support and retention. However, in long term denture wearers, this support and retention may become impaired, disabling them in normal daily activities. Implant treatment can overcome these difficulties, either by providing retention for removable dentures or supporting fixed prosthodontic appliances.

2.5.1. Implant-retained overdentures and OHRQoL

Implant-retained or implant-supported overdentures (IODs) are a type of removable dentures that are retained by implants, either freestanding or splinted, and supported by both the implants, the residual alveolar ridge and the overlaying alveolar mucosa. They rose to popularity as they provide far better retention and stability when compared to conventional CDs.

2.5.1.1. Maxilla

Due to the bone particularities and loading forces distribution in the maxilla, the suggested number of retaining implants is usually greater than in the mandible, ideally four to six, with delayed loading (61).

In a prospective study, Zembic et al. enrolled 21 subjects who received an overdenture retained with two titanium-zirconium implants with ball anchors. The mean follow-up was four years, when 16 patients were reevaluated. OHRQoL, assessed with OHIP-20, showed an improvement concerning physical, psychological, and social disability and handicap at one year and remained stable until four years (62).

Fonteyne et al. assessed the impact of IOD retained by four implants on OHIP-14 scores, overall health satisfaction, and speech (63). Twenty-one patients received a new/relined CD in the maxilla before implant placement. After four implants were placed and a healing period of four months passed, subjects received final IODs. Quality of life improved significantly after receiving IODs, and so did the overall health satisfaction and speech. At the three-year follow-up, OHIP-14 scores further improved.

In an RCT with a follow-up of one year, the impact of IODs retained by four implants with two different types of attachments on OHRQoL was compared (64). In addition, the researchers used another PROM in the study, the general satisfaction score (GSS). Fifty subjects in total, 25 per group, were allocated to receive four implants with either (i) bar or (ii) locator attachments. Both groups showed improvement in OHRQoL and GSS scores; however, this improvement was more significant for both measures in the bar group.

2.5.1.2. Mandible

IODs are usually retained by two or four implants in the mandible and show high treatment success rates.

However, a single implant can also be used to retain mandibular overdentures. Nogueira et al. (65) and Harder et al. (66) published results of their prospective studies with 45 and 11 subjects and two- and three-year follow-ups, respectively. Both studies reported a significant improvement in OHRQoL measures (OHIP-EDENT and OHIP-49) following loading of the

single implant with a mandibular IOD and the follow-up period. Both studies conclude that this treatment option is a feasible alternative in older individuals and those very poorly adapted to CDs. Policastro et al. (67) and Kronstrom et al. (68) reported on the outcomes of their RCTs, in which subjects were randomised to receive either one or two implants immediately loaded with a mandibular overdenture. In both trials, both treatments yielded a significant improvement in OHRQoL. However, in the trial of Policastro et al., a significantly greater improvement was observed at one-year follow-up for the IODs retained by two implants. In contrast, Kronstrom et al.observed no significant differences.

For IODs retained by two implants, the implants themselves are usually placed in the canine regions. This treatment modality, irrespective of loading timing or whether the implants are freestanding or splinted, also shows high treatment success rates (69–71).

In fact, in 2002, a panel of experts came up with a consensus statement, known as the McGill Consensus Statement on Overdentures, on the use of mandibular IODs as a standard of care, first-choice treatment for patients with complete edentulism (72). The statement informed that conventional CDs should no longer be considered the most appropriate treatment choice for completely edentulous patients. This was due to the increasingly growing body of evidence suggesting the superiority of IODs. In 2009, the British Society for the Study of Prosthetic Dentistry released a consensus statement on mandibular two implant-supported overdentures that further reiterated them as the first-choice treatment (73). The statement also focused on patient-centred outcomes, suggesting IODs are far superior in improving patient satisfaction and QoL than CDs.

Awad et al. conducted an RCT comparing two groups of CD wearers receiving new mandibular dentures: the first group received CDs (N=48), and the second group received two-implant IODs (N=54) (74). The researchers used OHIP-49 to assess the impact of oral status on the OHRQoL of the participants before the treatment and two months after they received new dentures. While an improvement was observed in both groups, the IOD group showed more significant improvement in OHIP-49 scores. A group of researchers of the Overdenture Effectiveness Study Team Consortium, led by Manal Awad, later conducted another multicenter RCT of a similar design with a total of 203 subjects (75). Changes in OHIP-20 scores after treatment suggested that, indeed, two-implant IODs yield more significant improvement when compared to CDs. Interestingly, subjects of different cultural backgrounds reported improvement in various domains of the OHIP-20; the subjects from

North America have, on the other hand, reported improvement in all the domains. The authors suggested these changes may be consequential to the different cultural values of various aspects of quality of life.

Harris et al. published similar findings. In an RCT they had conducted, 60 subjects per group, dissatisfied with their present complete denture, were randomised to (i) receive a new CD or (ii) two-implant IOD after wearing a new CD for three months. Subjects were assessed after six months from the beginning of the study (six months wearing CDs vs three months wearing new CDs and then three months of IODs). Researchers used OHIP-49 to assess the impact of the treatment on OHRQoL. They have also evaluated patient satisfaction with a Denture Satisfaction Questionnaire. Results of the study suggested that IODs were superior in improving both quality of life and patient satisfaction.

In addition to OHIP-49, Heydecke et al. also used Social Impact Questionnaire (SIQ) in their study, evaluating the impact of treatment with CDs and IODs. Interestingly, the SIQ managed to capture the more significant negative impact CDs have on kissing and sexual activities of subjects restored with this type of dentures, compared to IODs (76).

In a study by Jofre et al., implants used for two-implant IODs were small-diameter implants. Thirty patients in total were randomised into two groups: 15 received two splinted small diameter retained IOD, and 15 received no treatment (77). OHIP-EDENT was used for the assessment of OHRQoL. Even with this minimally invasive treatment modality, the OHRQoL of the subjects in the IOD group showed greater improvement when compared to the CD group after one year of follow-up.

Different two-implant IOD attachment systems do not seem to impact OHRQoL in a significantly different manner. Kleis et al. evaluated three different attachment systems, a self-aligning attachment system and two types of ball attachment systems (78). While OHIP-49 scores improved in all three groups at one-year follow-up, no differences among the groups were observed. In another prospective study, including 56 patients who received two-implant IOD on stud abutments (Locator), OHIP-14 showed continuous improvement up to five years (79).

Overdentures retained with a greater number of implants in the mandible, expectedly, also yield improvement in OHRQoL. In a prospective study with a follow-up of one year, Enkling et al. enrolled 20 subjects with complete mandibular edentulism and an existing CD (80). They have all received a mandibular IOD retained with four narrow-diameter implants.

OHRQoL was evaluated with OHIP-49, showing a significant reduction in scores evaluated at several time points over the course of one year. Interestingly, the most significant decrease in OHIP-49 scores was observed four weeks after providing new IODs. In addition, the study evaluated the bite force, which increased significantly with new IODs. Reissman et al. reported similar findings. Four narrow-diameter implants were placed and immediately loaded with an IOD. A significant improvement for all four OHIP domains, measured with OHIP-49, was seen four weeks after treatment and maintained over a five-year follow-up period (81). Čelebić et al. evaluated 176 patients in total with mobile anterior mandibular teeth that have received either (i) removable partial dentures (RPD), (ii) complete dentures (CD) after teeth extraction or (iii) four mini implant-retained IOD after teeth extraction (82). The impact of treatment on OHRQoL was evaluated with OHIP-14 at three months and two years after treatment. A significant reduction in OHIP-14 scores was observed in all treatment groups three months following treatment. The mini implant IOD group had a significantly greater reduction than the CD group, and it further improved until the two years follow-up. The authors also evaluated chewing function with Chewing Function Questionnaire (CFQ). Mini implant IOD group presented with the best improvement in chewing function at three months and two years.

A crossover RCT trial conducted by Karbach et al. intended to explore the impact of the number of implants on the improvement of OHRQoL, assessed with OHIP-14, in patients with complete mandibular edentulism seeking prosthodontic treatment (83). In the first part of the trial, all 30 enrolled subjects received new mandibular CDs and, afterwards, four small-diameter implants. After the healing period of eight weeks, the subjects were randomised to have either two (15 subjects) or four (15 subjects) implants incorporated in the overdenture. After three months, the retention concepts switched between the groups: the group that initially had two implants incorporated after three months got four implants incorporated, and vice versa for the other group. After additional three months, all four implants were incorporated in the locator-retained overdenture in both groups. The total study follow-up was one year when subjects were finally evaluated. This study significantly contributed to the existing knowledge on OHRQoL with the obtained data. It showed that OHRQoL already improves when patients who use CD (even new ones, as in this study) receive implant-retained overdentures. Furthermore, the number of implants seems to contribute to further OHRQoL improvements. There was a statistically significant difference between the two and four implants group in this study, with the four implants favouring a greater improvement.

A study by Allen and McMillan suggests that patient satisfaction and improvement of OHRQoL may also depend on the individual's attitude and perception of the received treatment (84). One hundred-three subjects were enrolled and allocated to four different treatment groups: (i) patients dissatisfied with the existing CDs, requesting and receiving implants for the purpose of retaining an IOD, (ii) patients dissatisfied with the existing CDs, requesting implant treatment, however for various reasons were not accepted for it and were instead offered a new CD, (iii) patients unaware of the possibility of implant therapy, receiving CDs, (iv) dentate subjects that served as a control group. Treatment was performed in both jaws. The groups of subjects requesting and receiving IODs or CDs reported significant improvement in QoL and satisfaction. However, the group that has requested implant treatment and an IOD, but has instead received CDs, only slightly improved both outcomes. The authors conclude that this finding could be consequential to the already existing bias of this group towards poorly functioning CDs and the inability to receive a "superior" treatment option.

Some studies evaluated the impact of implant-prosthodontic therapy on QoL using general QoL measures. For example, in a study by Fenlon et al. with a two-year follow-up, General Health Questionnaire (GHQ) was used (85). GHQ scores improved significantly and remained stable over the follow-up period. In another study, the improvement in QoL in a group of oncologic patients receiving maxillary or mandibular overdentures supported by four or six implants was evaluated using European Organization for Research and Treatment of Cancer quality of life questionnaires (EORTC QLQ-C30 and QLQ-H&N35) in addition to OHIP-14: significant improvements in all questionnaire scores were observed following treatment (86).

2.5.2. Implant-supported fixed complete dentures

With the advancement in implant-prosthodontic treatment, both removable and fixed implant-supported prostheses are now a reliable treatment choice for edentulism. Implant-supported fixed complete dentures (IFCDs) are a widely accepted treatment option in completely edentulous patients in both jaws. They are showing high long-term (up to 10 years) survival rates (87–89). The choice of treatment modality will ultimately depend on the general health,

clinical oral situation, and also the patient's treatment objectives – their willingness to undergo a specific modality of treatment and financial aspects of it.

In a one-year prospective study, Yamada et al. evaluated the impact of treatment with fixed maxillary prosthesis supported by four to six implants, loaded within two hours following surgery, on OHRQoL using the Japanese version of OHIP-54 (90). Patients reported improvement in QoL after one year. Similarly, in a two-centre study reported by Erkapers et al., 51 subjects with severely resorbed maxilla received a fixed maxillary prosthesis supported by six implants and loaded within 24 hours. The impact on OHRQoL was evaluated using the OHIP-49 questionnaire, and the patients were followed up for one year. After treatment, a significant improvement in all seven OHIP domains was observed. No significant difference between study centres was detected (91). The authors reported on the same cohort of subjects after three years of follow-up. Subjects continued reporting good QoL, even after three years (92).

In 2020 Higuchi et al. reported on the one-year outcomes of an innovative prefabricated mandibular three-implant fixed prosthesis in a population of 110 patients (93). In addition to clinical outcomes, the researchers evaluated the impact of the treatment on OHRQoL assessed with OHIP-EDENT and patient satisfaction. Significant improvements in OHRQoL scores were observed from baseline (prosthesis placement) to six months and baseline and one-year follow-up. Patients also reported significantly higher satisfaction with function after prosthesis placement.

Limmer et al. reported on the impact of four implants in the mandible, supporting a fixed prosthesis in a group of 17 patients (94). OHRQoL was evaluated with OHIP-49 at baseline (before new temporary CDs were produced), before implant surgery (after a period of wearing new CDs), and after six- and 12 months of implant surgery. Subjects experienced significant improvement in QoL already after having received new CDs and after receiving the fixed dental prosthesis. Good QoL was maintained over the 12 months, despite few prosthetic complications in ten out of 17 participants.

Berretin-Felix et al. evaluated the impact of treatment with mandibular five implant-supported fixed prostheses in 15 subjects aged 60 and more on OHRQoL and QoL, with a follow-up of 18 months (95). The researchers have used OIDP, OHIP-14, and a general QoL questionnaire, World Health Organization Quality-of-Life Scale (WHOQOL-BREF). After treatment, scores of the OHRQoL questionnaires showed improvement in most of the evaluated domains/items,

with continuous improvement over the follow-up period. Authors, however, also highlighted that the general questionnaire, WHOQOL-BREF, did not capture significant changes in the improvement, suggesting a lack of sensitivity. This is in line with previously discussed differences among condition-specific and general questionnaires evaluating OHRQoL vs general QoL.

GOHAI questionnaire was used in a study by Veyrune et al. to evaluate the impact of treatment with immediately loaded four to eight implants supporting a fixed prosthesis in the maxilla or mandible in 14 subjects followed for six months (96). GOHAI scores improved in all domains after implant loading.

El Osta et al. reported on a study including three groups of patients treated with CDs, IODs and implant-supported fixed prostheses (the number of dental implants was not specified) in both jaws (97). The study assessed the nutritional status of the subjects, in addition to OHRQoL assessed with GOHAI. Both groups of implant-supported prostheses showed significant improvement in OHRQoL compared to CDs following treatment; however, no significant difference could be observed between the fixed prosthesis group and IOD group at any follow-up time point.

In a study by Elsyad et al., 16 subjects with the primary complaint of ill-fitting mandibular denture were enrolled. The subjects have initially received new mandibular CDs and have worn them for three months. They have then received four implants installed according to the "All-on-four" concept, loaded with the mandibular denture. Eight patients received a fixed prosthesis after the osseointegration period of three months, while the other eight received a milled bar overdenture. After additional three months, the groups have switched the prosthetic modality. OHRQoL was assessed with OHIP-14. Improvement in OHRQoL was observed after subjects had received the fixed prosthesis and the milled bar overdenture – no differences among the groups could be observed. The fixed prosthesis was rated with greater retention, chewing, and stability satisfaction. In contrast, the subjects rated the milled bar overdenture for its ease of handling and cleaning. Data on the OHRQoL changes following "All-on-four" concepts in both maxilla and mandible was also published by Misumi et al. (98), Ayna et al. (99), and Babbush et al. (100). Misumi et al. used the Japanese version of OHIP-14 – in the study, the OHRQoL significantly improved only after the definitive protheses were placed, while this could not be observed for the initial and interim prosthesis. Ayna et al. used OHIP-49 and reported a dramatic decrease in OHIP scores following two

different types of prostheses delivery (metal-ceramic implant-supported fixed prosthesis vs bar-retained removable prosthesis), with results that remained stable even after seven years. In the study by Babbush, the Edentulous Patient Impact Questionnaire (EPIQ) was used, and the results suggested high satisfaction with the treatment. Patient satisfaction, another PROM, was also positively affected by treatment with the "All-on-four" concept, in particular in studies by Francetti et al. (101), Sannino and Barlattani (102) and Capelli et al. (103).

Dierens et al. reported on the results of a study in which 28 subjects were treated with fixed prostheses supported by five to eight implants, immediately loaded, in either maxilla or mandible (104). Using 100mm VAS for scoring questions in a self-administered questionnaire, patients evaluated their satisfaction. Patients were followed-up at one week, three or six months and one year. Self-perceived satisfaction improved significantly already one week after treatment. Further improvement was observed after the final full-arch construction was installed at three months in the mandible and six months in the maxilla. While patients reported a rise in satisfaction with their aesthetics, function and comfort, eating comfort showed the greatest improvement.

2.6. Implant-prosthetic therapy of partial edentulism and OHRQoL

Conventional prosthodontic treatment modalities for partially dentate subjects include removable partial dentures (RPD) and fixed partial dentures (FPD), the latter being preferred by patients. Traditional tooth-supported FPDs are a reliable and widely used treatment modality, yielding good long-term results. However, with the increasing use of dental implants, single implant-supported crowns or implant-supported FPDs are becoming a treatment modality alternative.

Unlike the abundance of data on the implant-prosthodontic rehabilitation of complete edentulism, as stated in a systematic review by Bruyn et al. in 2015 (105), there is a need for a greater number and higher-quality studies assessing OHRQoL and other PROMs for implant-prosthodontic rehabilitation of partially dentate subjects.

2.6.1. Single implant-supported crowns

Patients are more likely to see the importance of and seek prosthodontic treatment in case of missing anterior teeth (106). Namely, aesthetics rather than function seems to determine an individual's need to replace a missing tooth (107).

Dong et al. analysed data from 373 who underwent single-implant placement in both jaws and the anterior and posterior regions (108). The Oral Implant Impact Profile Questionnaire (OIIP-Q), containing 15 questions, assessed patient satisfaction. Obtained data suggest high satisfaction of patients following treatment. However, the need for bone augmentation and a more extended period of edentulism were associated with lower satisfaction scores. As a secondary outcome, Raes et al. evaluated OHRQoL in subjects that have received a dental implant in the anterior region, in healed alveolar bone sites or following tooth extraction, with or without grafting (109). Patient satisfaction and OHIP-14 scores in all seven domains were significantly improved after one year.

In the pilot study of Van Lierde et al., the impact of a single implant (upper central incisors) in the anterior region on OHRQoL was assessed using OHIP-14 18 months after implantation (110). Satisfaction with the implants was evaluated using VAS. Six subjects reported problems in the domains of functional limitations, physical disability and psychological discomfort and disability. Satisfaction was rated with a mean of 95%.

Goshima et al. reported on the study that included 18 subjects with tooth agenesis treated with a single implant-supported restoration, mostly in the premolar area (111). OHRQoL was assessed with OHIP-49. The masticatory function was also assessed. Following treatment, there was a significant improvement in OHRQoL, as well as patient- and clinically-perceived improvement in masticatory efficiency.

As discussed previously, the severity of tooth loss affects and contributes to the impairment severity of OHRQoL. As such, the pre-treatment status and the expected post-treatment changes in partially (one or more missing teeth) and completely edentulous subjects are significantly different. Fonteyne et al. investigated the impact of implant-prosthodontic treatment on OHRQoL and social participation in a group of subjects with a single implant-supported restorations and completely edentulous subjects (112). In the case of single-restoration subjects, the impact of treatment on QoL and social participation, assessed with OHIP-14, was minor compared to subjects requiring comprehensive treatment. Interestingly,

as the researchers have also evaluated the subjects' personality traits, it seems that traits of (lower) Neuroticism and (higher) Extraversion before and after treatment are related to higher reported QoL.

2.6.2. Implant-supported fixed partial dentures

Similar to Fonteyne et al., Sghaireen and Al-Omiri evaluated the impact of implant-supported fixed partial dentures (IFPD) in the anterior maxillary region on OHRQoL, measured using the DIDL questionnaire assessed personality profiles of 59 enrolled subjects (113). OHRQoL scores generally improved after treatment. When assessing data between the sexes, the female subjects expressed less satisfaction before but more after treatment. The authors also concluded that specific personality profiles (Neuroticism, Conscientiousness, Openness, Extraversion) might impact the subjects' perceptions of tooth loss and its influence on daily living and satisfaction with treatment.

Yu et al. enrolled 238 patients who had received an IFPD instead of the existing RPD in the anterior region (114). The researchers have used the Chinese version of OHIP-14 to assess the impact of partial edentulism on OHRQoL before and after the treatment. After treatment, a significant improvement was observed among the subjects. Education level was highlighted as an important factor that may influence QoL. In the study, subjects with higher education levels reported significantly greater OHIP-14 scores following treatment than lower education subjects, suggesting worse self-evaluated QoL. As the authors highlighted, this could be consequential to greater knowledge on the matter of oral health and expression of greater concern about the possible outcomes.

Fillion et al. included 77 subjects treated with a single implant, 75 subjects rehabilitated with IFPD and 24 completely edentulous subjects rehabilitated with IFCD. After treatment, patients with complete edentulism reported the greatest improvement in OHRQoL. It is important to highlight that the partially dentate subjects had less impaired OHRQoL to begin with, further reiterating the impact of severity of tooth loss on OHRQoL (115).

Peršić and Čelebić enrolled patients that initially had partial and complete conventional prosthodontic appliances (116). They were assigned to receive various prosthodontic treatment modalities, as follows: 70 subjects received CDs, 37 subjects IODs, 56 subjects

RPDs, 15 subjects implant-supported RPDs, 25 subjects FPDs and 56 patients IFPDs. Croatian version of OHIP-14 was used to assess OHRQoL after treatment. The subjects that received IODs and implant-supported RPDs benefited the most from the treatment (greatest change between pre- and post-treatment OHIP-14 scores). Subjects that have received FPDs and IFPDs reported the lowest post-treatment OHIP scores, suggesting the best quality of life.

Petričević et al. reported on the comparison of OHRQoL, assessed with OHIP-49, of two groups of partially dentate subjects that have received either FPD or IFPD and a control group (117). IFPD group consisted of subjects receiving either a single tooth restoration or an implant-supported bridge. OHIP-49 was administered at baseline, three weeks, and three years after final prosthodontic treatment was delivered. OHRQoL significantly improved already three weeks after treatment. After three years, there was further improvement in both groups. Interestingly, when the two groups were compared at all three-time points, the IFPD group had significantly higher scores of OHIP-49, suggesting a lower quality of life.

Sonoyama et al. compared subjects that have received either an IFPD or a resin-bonded bridge. The researchers used a self-administered QoL questionnaire (118). The questionnaire assessed two subscales, the oral- and general condition-related subscales. The two groups did not significantly differ in terms of QoL scores.

On the other hand, Furuyama compared the OHRQoL of subjects with IFPDs and RPDs. The results highlighted that patients with IFPDs had a generally better OHRQoL than patients with RPDs (119).

3. DISCUSSION

Tooth loss has far-reaching consequences when not timely addressed. It negatively affects self-perceived aesthetics, normal oral functions, and psychosocial well-being. There is a substantial body of evidence on the clinical outcomes of "traditional" modalities of oral rehabilitation. We are also witnessing a tremendous increase in published data on oral rehabilitation with dental implants in recent years and decades.

PROMs have been used in medicine for far longer than in dental medicine. In fact, in the field of dental implantology, in particular, the use of PROMs was first prompted in 2011 at the VIII European Workshop on Periodontology, focusing on the quality of reporting of experimental research in implant dentistry (120). In 2018 a consensus report, based on the Proceedings of the Sixth ITI Consensus Conference, was published, reporting on the PROMS associated with implant dentistry. The consensus group concluded that PROMS should be a constituent part of every clinical study assessing the outcomes of oral rehabilitation with dental implants (121). Moreover, it was highlighted that PROMs, of which patient satisfaction and OHRQoL are just part, should accompany clinical parameters in our clinical definition of successful treatment.

Based on this suggestion, when planning treatment, the additional question asked should be: "Among the clinically proven implant-prosthodontic treatment modalities, which ones benefit completely and partially edentulous patients the most in terms of improvement of their OHRQoL?"

The far greatest body of evidence on the impact of implant-prosthodontic treatment on OHRQoL exists on the oral rehabilitation of completely edentulous individuals and, in particular, IODs and their comparison to CDs. In addition, the most significant number of published research focuses on the rehabilitation of the completely edentulous mandible.

In fact, several systematic reviews and meta-analyses were performed in the recent period, and the results mainly reported on the aforementioned treatment modality. One of the earliest systematic reviews on the topic, Thomason et al. from 2007, aimed to evaluate the impact of reconstructive treatment of edentulous patients (122). The review reported that the existing evidence suggests that mandibular IODs perform better in terms of patient satisfaction and improvement of OHRQoL. The data on rehabilitation with maxillary IODs was limited, and robust conclusions could not be drawn. Similar findings were published around the same time in a literature review by Strassburger et al. (123).

In 2009 Emami et al. performed a systematic review and meta-analysis comparing CDs and IODs in terms of patient satisfaction and OHRQoL, however, they have purposefully included only RCTs (124). Only 6 RCTs could be included in the review. Evidence indicated that patients were generally more satisfied with IODs, however, no evidence could be found on the superiority of IODs in terms of OHRQoL. In 2015, Boven et al. published another systematic review on the performance of IODs (125). While compared to CDs, the use of IODs yielded greater patient satisfaction in terms of comfort and chewing ability. The impact on OHRQoL could not always be observed, and as such, the authors concluded that the effect of this treatment modality on QoL is still uncertain. Like the previous systematic reviews, the authors highlighted that most of the studies investigated mandibular IODs. A year later, in 2016, Sivaramakrishnan and Sridhara published a systematic review and meta-analysis of RCTs comparing CDs and IODs in terms of OHRQoL (126). The result of the analysis of five studies suggests that IODs perform better than CDs in improving OHRQoL, measured through OHIP questionnaires. The same authors later compared IODs supported by mini- and standard dimension implants (127). The available evidence suggests that mini-implant IODs provide greater patient satisfaction and QoL. However, the authors highlighted that results should be interpreted with caution due to the limited number of studies. Kutkut et al. published a systematic review in 2018 comparing CDs and IODs retained with unsplinted implants (128). The authors concluded that IODs are superior to CDs in terms of improvement in QoL and patient satisfaction, and chewing efficiency.

In 2018, Yao et al. compared IODs and IFCDs in both jaws, including 13 studies in their systematic review (129). No significant differences could be found between the two treatment modalities, and in fact, the authors reported conflicting results. However, a systematic review (ten studies) by Borges et al. reviewing the same treatment modality only in the mandible reported that IFCDs seem to be superior in improving certain domains of OHRQoL (functional limitation, physical disability and physical pain), and also patient satisfaction (130).

In January 2022, a systematic review by Yaguinuma Goncalves was published, which analysed OHRQoL and patients satisfaction in patients treated with the "All-on-four" concept (11 studies). Reported OHRQoL and patient satisfaction were high, however, authors highlighted the still limited evidence (131). Shortly thereafter, a systematic review from Saez-Alcaide et al. on zygomatic implant-supported complete dental prostheses was published.

Again, patients reported significant increases in OHRQoL, general satisfaction, function (chewing) and aesthetics (132).

As it was mentioned before, the published data on dental implant treatment in partially dentate individuals is still lacking. Thomason et al. already in 2007 highlighted the scarcity of data on modalities of rehabilitation other than treatment of complete edentulism. Reissmann et al. in 2017. reported that following treatment with IFPD, patients report improvement in OHRQoL (133). However, when IFPD were compared with tooth-supported FPD, their performance in terms of OHRQoL was not superior. There was moderate evidence suggesting that IFPD improved OHRQoL more than RPD.
In 2019 Ali et al. compared prosthodontic treatment modalities for partially dentate subjects (134). All treatment modalities, removable and fixed, improved OHRQoL. However, IFPD seems to improve more than tooth-supported FPD and RPD. Ramani et al. published in 2020 a systematic review and meta-analysis assessing the outcome of treatments with single- or multi-unit IFPD in the aesthetic zone (135). An improvement of OHRQoL was observed post-treatment. Furthermore, the authors highlighted that the number of restored units/teeth might impact the post-treatment changes in QoL.

There is a continuous, growing interest in PROMs among researchers in dental medicine, which is reflected by the increasing number of published studies in the recent decade. However, it is essential to highlight the limitations of the published literature hitherto that disables producing strong evidence-based, clinically meaningful information.

As consequences of tooth loss affect systems outside of the oral cavity, it is worth highlighting that more data is needed to understand whether the restoration of edentulous areas can also positively impact systemic health. A systematic review by Gennai et al. produced for the Periodontitis stage IV Treatment Guidelines Workshop evaluated the effect of both conventional and implant-prosthodontic treatment on systemic biomarkers in addition to OHRQoL (136). While it seems that masticatory efficiency indeed improves, more data is needed to understand its impact on nutritional status, frailty and also cognitive function.

Finally, some of the significant limitations in evaluating the OHRQoL literature are the variety of PROMs and scoring systems used across the studies. Furthermore, some of them are not validated for an edentulous subpopulation. This creates difficulty in interpreting the treatment outcomes and comparison among different studies and systemising and analysing data in reviews and meta-analyses. In 2012 already, Lang and Zitzmann proposed the

development of a standardised implant-specific PROM. Treatment protocol and post-treatment follow-ups are also not standardised, which further contributes to the existing noise in the evidence.

However, clinicians should be aware that the existing data, despite limitations, already indicates that oral rehabilitation significantly impacts OHRQoL. The available data suggests and supports the rationale for rehabilitating edentulism and should be recognised as an influential factor in improving QoL and potentially systemic health.

4. CONCLUSION

Within the limitations of this narrative review, there is a clear association between oral rehabilitation, in particular, implant-prosthodontic treatment of edentulism and improvement of OHRQoL.

A robust body of evidence suggests that IODs are superior to CDs in improving OHRQoL, particularly in the mandible. However, more data is needed for treatment in the maxilla to draw firm conclusions. The improvement in OHRQoL can be observed when mini-, narrow- and standard diameter implants are used. The higher number of implants (e.g. two vs four) is not necessarily associated with a more significant OHRQoL improvement. IFCDs in both jaws are also associated with improved QoL, significantly more so than CDs.

More studies assessing OHRQoL and implant-prosthodontic treatment in partially dentate subjects are warranted. Single- and multi-unit IFPDs are associated with the improvement in QoL. Studies suggest this improvement is greater than when RPDs are used and, in some cases, compared to tooth-supported FPDs.

Clinical implant treatment outcomes are indispensable for evidence-based, meaningful treatment protocol. However, PROMs, such as OHRQoL, should be considered as they inform clinicians on the patient's subjective assessment – the individual who needs to function with the treatment we have provided.

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6. CURRICULUM VITAE

Larisa Musić earned a doctor of dental medicine degree from the University of Zagreb School of Dental Medicine in 2014. She is a specialist in periodontology, having obtained her specialist title in 2020. In addition, she holds a doctoral degree from the University of Zagreb, having graduated in 2021. Since 2015, she has been employed full-time as a teaching and research assistant and since 2021 as a postdoctoral researcher at the Department of Periodontology, University of Zagreb School of Dental Medicine.