The purpose of this study was to review the impact of loss of teeth and the current state of treatment options available for oral rehabilitation of edentulism. Function with complete dental prostheses varies based on a patient’s ability to adapt to removable prostheses and their psychologic acceptance of the treatment. There is varying dissatisfaction with removable prostheses, particularly in Western economies. This is driven in part by the availability of oral implants, which have transformed the treatment options for oral rehabilitation in general and for edentulous rehabilitation in particular. Quality-of-life studies have confirmed the advantages of implants for the retention and support of dental prostheses, as they improve function and esthetic measures to nearly those of the dentate state. Osseoperception, the concept of feedback to the sensorimotor system from tissues surrounding osseointegrated implants, contributes to enhanced function with implant treatment. It is recognized that tooth loss resulting in the loss of periodontal mechanoreceptors has a detrimental effect on jaw motor control even after implant treatment. However, despite this limitation, oral rehabilitation with or without implants, which improves function and esthetics, helps maintain psychosocial and cognitive health. Int J Prosthodont 2022;35:575–580. doi: 10.11607/ijp.8211

Oral rehabilitation enhances esthetics and function. Given media influences, it appears that psychosocially aware societies prioritize esthetics, with high expectations for the preservation or restoration of beauty, elegance, and social desirability, as well as function (communication; mastication and swallowing [diet and nutrition]), social interaction, and self-esteem, all of which contribute to enhanced quality of life. The media is a major influence on how bodily appearance is perceived, with emphasis on rewards for greater physical attractiveness. Studies indicate that people look longer and more often at faces perceived as “attractive” than those perceived as “unattractive.” Further, viewing “attractive” faces recalibrates individual preferences to match the characteristics of the “attractive” faces rather than the characteristics of the population average. The constant barrage of media promotions and images has driven contemporary consumer culture to place greater importance on appearance and the management of personal impressions.

This increased attention to maintaining the body and face, in particular for social and esthetic reasons, in conjunction with the prevailing Western cultural circumstances and expectations enables such transformations and makes the contemporary body...
a “plastic” one.5 As Slater commented: “The body can be taken as a reflection of the self because it can and should be worked upon.”6

The human face is described as “a highly specialized part of the body and the most convincing proof of an individual’s identity.”7 McNeill maintains that “the living face is the most important and mysterious surface we (oral health practitioners) deal with...the centre of our flesh. We eat, drink, breathe, and talk with it.”8 Pennebaker comments that the face is a “social advertisement for who we are.”9 This being the case, the quest for “better looking” faces should no longer be considered only as vanity, but as a significant means of “self-fashioning,” where appearance, meaning, and identity merge and evolve.

On the other hand, it would appear that developing economies prioritize function, as this is often the driver of survival, and esthetics under these circumstances have more modest expectations. Masticatory function is linked to the number of teeth or their replacements, which influences jaw muscle function and bite force generation. The primary goal of masticatory function is enhanced diet and nutrition for improved general health, and its secondary goal is the recently recognized contribution to maintenance of higher-level cerebral function and cognition.

This narrative review addresses the challenges associated with the aging world population and the benefits of oral rehabilitation with implant-supported vs tissue-supported complete dental prostheses (CDPs) following teeth loss.

IMPLICATIONS OF LOSS OF TEETH

Although the retention rates for natural teeth have increased dramatically and the percentage of edentulous adults has decreased progressively over the last 30 years, the demand for CDPs continues due to the “greying of the community.”10 As the world population ages, treatment demands change with the increasing number of older adults. United Nations data from 2008 indicate that in industrialized nations, persons over the age of 60 years will increase from 264 million in 2009 to 416 million by 2050.11 The US Census indicates that from 2014 to 2060, the US population will increase from 319 million to 417 million. The population is projected to age over the coming decades, with the percentage aged 65 and over expected to grow from 15% to 24%, an increase of 9% between 2014 and 2060. In contrast, the population aged 18 years and under is projected to decrease from 23% to 20%, and the population aged between 18 and 64 years is projected to decrease from 62% to 57% over the same interval.12 Weintraub and Burt predicted a progressive decrease in edentulism of 30% by 2020; however, the actual number will increase with people living longer, as will the demand for CDPs.13

It is consistently reported that continuing loss of teeth in the maxilla and mandible without replacement has impacts on function and quality of life14 and is associated with malnutrition,15 mortality, and disability.16 It is also associated with loss of cognitive function17 and increased prevalence of dementia.18 It is clear that, into the foreseeable future, the ongoing and significant demand for improved management of edentulism poses a major challenge for our profession. In this context, the acknowledgment that aging is a risk factor for developing dementia19 implies that an increase in patients suffering from dementia is also anticipated.20 Other risk factors for developing dementia include Alzheimer’s disease (a more common form of dementia), illiteracy, lower level of education and lower socioeconomic status,21 and tooth loss.22,23

OUTCOMES WITH REMOVABLE CDPS

Zarb has reported that “...prosthodontists have been remarkably successful in treating difficult edentulous patients with complete dentures.”24 Nevertheless, quality of life outcomes indicate that in industrialized economies, there is general dissatisfaction with CDPs. Although significant, this is not absolute, and CDP wearers report varying degrees of success, which is a patient-specific measure based on past experiences, confidence, and psychosocial influences. However, in the majority of patients, inadequate adaptation appears to occur. Edentulism and removable prostheses are considered a significant handicap for oral function and psychosocial well-being.25–28

The availability of oral implants has transformed treatment options, and in 2002 and 2012, the McGill and the York consensus statements proposed a “standard of care” for the edentulous mandible calling for implant support for overdentures.29 This term has been challenged, as it undermines alternatives where patient interests are different and resources are limited, and an alternative “minimum acceptable protocol” has been proposed by Owen.30 However, it is an almost universal experience that CDPs impact function, diet and nutrition, esthetics, and psychosocial well-being to varying degrees.31 Systematic reviews on masticatory performance have reported that mandibular implant-supported overdentures opposing a maxillary CDP significantly improved these functional and psychosocial variables.31,32 Rohlin et al reported that evidence for the treatment of edentulous patients was poor, but general trends indicated that: (1) the survival of mandibular fixed implant-supported prostheses was higher at 10 years compared to similar prostheses in the maxilla at 5 years; and (2) fixed implant-supported prostheses were in general more...
successful than removable implant- and tissue-supported prostheses.\textsuperscript{33}

Fixed implant prostheses with 4 to 6 implants interforaminally and screw-retained cantilevered prostheses were the treatment of choice by Brånemark et al for the edentulous mandible,\textsuperscript{26} and patient acceptance has been found to be high.\textsuperscript{28} In the mandible, the distinct anterior curvature of the jaw favors a fixed prosthesis design, as it is biomechanically more favorable for loading. Ideally, implants are distributed around the arch to avoid long cantilevers, and this approach is now more commonly implemented. The edentulous maxilla managed with a CDP does not present the same consistent difficulty as a mandibular CDP. It is, however, technically more demanding given the variability of maxillary bone, esthetics, and speech requirements. Routinely considered alternatives to CDPs are implant-retained overdentures or fixed implant-supported prostheses,\textsuperscript{34} but it is acknowledged that implants may not be indicated because of patient preference, inadequate bone volume, or medical contraindications such as past radiotherapy or long-term use of bisphosphonates.

An essential requirement for successful outcomes is informed consent to ensure compliance, understanding, and support for optimizing implant rehabilitation, and in particular for ensuring that psychosocial variables are satisfied. Data from oral health–related quality of life (OHRQoL) (Fig 1) and psychological profile questionnaires (Fig 2) have confirmed the multiple benefits of implant retention and stability for optimizing function and quality of life outcomes to values approaching those in dentate patients. These tools are in routine use in the specialty prosthodontics program at the University of Sydney for before-and-after treatment assessments.

The questionnaire shown in Fig 1 is used to evaluate prosthesis satisfaction. The questionnaire assesses quality of life aspects such as food, speech, general health, and relaxation/sleep and shows improvements in most domains for CDPs, implant overdentures, and implant-supported fixed prostheses. The graphs generated from the psychologic profile (Symptom Checklist 90 Revised [SCL-90-R]) questionnaire (Fig 2) indicate a progressive transition with improvement from the old CDPs (blue) to the new CDPs (red), to a mandibular implant overdenture (gray), to a mandibular fixed dental prosthesis (black). With these transitions, there is a progressive reduction in the 6 key parameters of psychologic assessment. The graphs show a reduction in levels from over 65 for anxiety and 65 for interpersonal sensitivity to below 50 with the implant-supported mandibular prosthesis. This assessment tool considers 65 as the level above which further management may be needed with a clinical psychologist, and levels below are clinically acceptable.

\textbf{PROPRIOCEPTION AND OSSEOPERCEPTION}

Osseoperception was proposed by Brånemark to describe the multiple physiologic feedback mechanisms responsible for enhanced function with implants and by
extension the enhanced OHRQoL outcomes expected as a result of implant treatment. The implication that bone contains proprioceptive feedback capability has been considered over three decades and summarized by van Steenberge35 and colleagues.36–38

A consensus meeting in Sydney39 addressed this issue with a statement that: "Osseoperception may be considered to be the mechanosensitivity associated with osseointegrated implant rehabilitation. This phenomenon may be defined as (1) the sensation arising from mechanical stimulation of a bone-anchored prosthesis, transduced by mechanoreceptors that may include those located in muscle, joint, mucosal, cutaneous, and periosteal tissues; together with (2) a change in central neural processing in maintaining sensorimotor function." These feedback mechanisms are the ones for which there are data. There may be feedback from bone as well, but this is not clear.

As implied by these findings, the mechanism of osseoperception has a global feedback basis. This was addressed by proposing a hierarchy of feedback from tissues surrounding implants that are responsible for the resulting improved function.40–42 It was also emphasized that osseointegration-linked osseoperception is the key to rehabilitation of function facilitated by the rigid fixation of implants to bone. This allows for functional forces to be transferred to bone and associated tissues, leading to activation of a range of mechanoreceptors and feedback to the sensorimotor cortex to modulate function.

Laurell and Lundgren have added to this information with specific clinical studies designed to examine details of functional implications of individuals with tooth-supported or implant-supported fixed prostheses. Their data indicate that food is prepared for swallowing in a similar manner to those with a natural dentition.43

Kleinfelder and Ludwig reported that experimental splinting of posterior teeth in subjects with reduced periodontal tissue support (where approximately 50% of the periodontium remained) or healthy periodontal tissues allowed for an approximately 40% increase in maximal biting force.44 Further, Waltimo and Könönen also reported that splinting anterior teeth allowed for a higher maximal bite force.45 However, the results of bite force studies with implant-supported prostheses have been inconsistent compared to natural teeth, and maximal bite force for implant patients is dependent on the dental status of the opposing teeth and varies with time.46–51

In recognition of this information, Trulsson reported that when teeth contact food, periodontal mechanoreceptors (PMs) signal detailed information to regulate both manipulative and power aspects of jaw function. As a result, it was predicted that in mastication, loss or impairment of PMs resulting in lost or reduced sensory feedback would generate higher and more variable bite force levels and a reduced capacity to modulate the force to the hardness of the food.52,53 This was assessed during simple "hold-and-split tasks" with brittle foods of different hardness in subjects with: (1) natural teeth (intact PMs); (2) tooth-supported fixed prostheses in both arches (impaired sensory information from PMs); and (3) implant-supported fixed prostheses in both arches (no PMs). Forces applied during the holding and split phases provided data confirming that loss of sensory signals from PMs had a detrimental effect on jaw motor control in patients with dental implants.54–58

**OCCLUSION AND BRAIN FUNCTION**

A requirement of crucial importance for optimizing masticatory function is a stable occlusion. Data are
accumulating to indicate that cognitive aging and impairment of executive function are directly linked to impaired mastication. Executive function influenced by mastication may include: (1) general level of brain activity controlled through the reticular activating system; (2) episodic memory; and (3) learning new information. 

Brain areas linked to executive function include the prefrontal cortex, striatum, cerebellum, and hippocampus. These areas are sensitive to aging, and dysfunction of the hippocampus causes episodic memory loss. Animal studies support these clinical implications and confirm that a soft diet requiring reduced mastication leads to cognitive decline and loss of ability to learn new tasks.

CONCLUSIONS

Priorities for health management include the desire to retain youth, beauty, and optimal function. These drivers of behavior have emerged as a byproduct of the latest education and knowledge, and the will to succeed has extended the survival instinct of the past to a focus on self-preservation. This commitment to maintenance of esthetics and health will continue to mold behavior.

In this context, contemporary oral rehabilitation treatments have made traditional CDPs less acceptable with the awareness that oral health and functional rehabilitation are achievable. Implant rehabilitation based on osseointegration-led osseoperception has driven this outcome. However, data have confirmed that although implant rehabilitation predictably restores esthetics and function, it does not restore equivalence with natural dentition, and importantly, some patients satisfactorily manage removable prostheses without implant treatment.

In general, however, the functional and often aesthetic advantages of fixed prostheses with improved psycho-social outcomes are further enhanced with the maintenance and possible restoration of cognitive health and higher-level cognitive function.

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REFERENCES

This study aimed to identify clinical and radiographic characteristics of teeth with longitudinal fracture to assist in the differential diagnosis of cracked teeth and teeth with vertical root fracture (VRF). A total of 95 patients (95 teeth) diagnosed with a longitudinal fracture (only cracked teeth or VRF) through clinical visualization of the fracture line were included in this study. Clinical and radiographic data were collected from patient records to identify the characteristics associated with each condition. Of the included patients, 54 (54 teeth) had full frontal teeth. Scand J Dent Res 1994;102:372–375.

CBCT Patterns of Bone Loss and Clinical Predictors for the Diagnosis of Cracked Teeth and Teeth with Vertical Root Fracture

This study aimed to identify clinical and radiographic characteristics of teeth with longitudinal fracture to assist in the differential diagnosis of cracked teeth and teeth with vertical root fracture (VRF). A total of 95 patients (95 teeth) diagnosed with a longitudinal fracture (only cracked teeth or VRF) through clinical visualization of the fracture line were included in this study. Clinical and radiographic data were collected from patient records to identify the characteristics associated with each condition. Of the included patients, 54 (54 teeth) had full radiographic (periapical [PA] radiography and a CBCT scan) and clinical (probing depths and clinical images of the fracture line) findings. PA and CBCT images were evaluated by two independent examiners to identify the different patterns of bone loss associated with these teeth (ie, no defect, angular defect, J-shaped defect, or combined defect). Cohen kappa analysis was used to compare the results between the two examiners and between the findings of the PA and CBCT images. Pearson chi-square analysis, Fisher exact test, and adjusted Bonferroni post hoc testing were used to establish whether there was an association between the type and extension of longitudinal fracture and the probing depth, CBCT pattern of bony defects, and presence/absence of the buccal plate, as well as to compare the clinical and radiographic characteristics of cracked teeth and teeth with VRF (P < .05). Compared to PA radiographs, CBCT images had 4.4 times the odds of detecting bony defects suggestive of longitudinal fracture. Teeth with VRF showed higher associations with indirect restorations, deep probing (> 6 mm), absence of the cortical plate, and presence of a J-shaped defect on the CBCT image (P < .001). There was a significant correlation between radicular extension of the fracture line and deep probing as well as J-shaped defects (P < .05). It was concluded that the patterns of bone loss on CBCT imaging can likely differentiate between cracked teeth and teeth with VRF. The presence of an angular defect may suggest the presence of a crack in the tooth before intervention. J-shaped defects, deep probing (> 6 mm), and loss of the cortical plate are likely suggestive of VRF.

Alaugaily I, Azim AA. J Endod 2022;48:1100–1106. References: 27. Reprints: A. Azim, aazim@pacificu.edu — Carlo Marinello, Switzerland


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