The Impact of Implant Supported Removable Partial Dentures Supported by Short Implants on Oral Health Quality of Life

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Abstract

William Day Gates III: The Impact of Implant Supported Removable Partial Dentures Supported by Short Implants on Oral Health Quality of Life
(Under the direction of Ingeborg De Kok)

For decades, removable partial dentures (RPDs) have been a standard treatment for partial edentulism despite major shortcomings. To alleviate these problems, implants have been incorporated to provide additional support, increase stability, and maintain bone. This prospective study incorporated dental implants to evaluate; a comparison of impact on oral health quality of life RPDs and implant supported removable partial dentures (ISRPDs); prosthetic outcome of ISRPDs; 6 month survival of 6mm Astra-tech implants. Ten patients received new RPDs, but prior to fabrication of a RPD, 6 mm dental implants were placed in the posterior edentulous areas. Examination of oral health occurred at 6 weeks and 12 weeks after delivery of the RPD. At 12 weeks, attachments were inserted and the RPD was converted to implant ISRPD. Subsequent follow-ups at 18 weeks and 26 weeks demonstrated a statistical improvement in oral health quality of life. All sixteen implants survived.

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Table of Contents

List of Tables vii

List of Figures viii

List of Figures viii

1 INTRODUCTION 1

1.1 Partial edentulism and need for prosthodontic treatment 1

1.2 Shortfalls of conventional removable partial denture therapy 3

1.3 Current research with implant supported removable partial dentures 7

1.4 Oral Health Impact Profile 11

1.5 Short dental implants 11

1.6 Aim of the study 13

2 MATERIALS AND METHODS 15

2.1 Patient Selection 16

2.2 Inclusion and Exclusion Criteria 16

2.3 Prosthodontic and dental implant treatment 17

Visit 1 – Diagnosis and treatment planning 17

Visit 2 – Survey with cone-beam tomography 18

Visit 3 – Placement of implant body 18

Visit 4 – Survey crown preparations (if required) 20

Visit 5 – Final impression for removable partial denture 21

Visit 6 – Record maxillomandibular relationship 22

Visit 7 – Framework try-in 22

Visit 8 – Wax/tooth try-in 22

Visit 9 – Delivery of conventional removable partial denture 23

Visit 10 – 1 week follow up 23

Visit 11 – 6 week follow up 23

Visit 12 – 3 month follow up of RPD treatment, uncover of implant, and conversion of RPD to ISRPD 23

Visit 13 – 1 week follow up 25

Visits 14, 15 – 6 week, 3 month follow up 25

2.4 Measurement of outcomes 26

2.5 Statistical analysis 27

3 RESULTS 29

3.1 Oral Health Impact Profile (OHIP-49) 29

3.2 Prosthetic Complications 34

3.3 Implant Survival 35

4 DISCUSSION 36

5 CONCLUSION 40

Appendix A 41

References 45

List of Tables

Table 3.1 Selected Characteristics of Study Participants and Mean (s.e.) OHIP-49 Severity Score at Baseline (n=10)..... 30

Table 3.2 Difference in mean OHIP-49 severity scores at Visits 2-5 relative to Visit 1baseline levels (n=10) 31

Table 3.3 Difference in mean OHIP-49 severity scores at Visits 1,2, 4 and 5 relative to Visit 3 levels (n=10) 32

Table 3.4 Prosthetic complications encountered during treatment with RPDs and ISRPDs 35

List of Figures

Figure 2.1 Kennedy Class I Mandible 18

Figure 2.2 Kennedy Class II modification 1 mandible 18

Figure 2.3 Cross sectional image from a CBCT 18

Figure 2.4 Implant body in position with cover screw 20

Figure 2.5 Periapical radiographs after implant placement 20

Figure 2.6 Immediately following abutment placement. Clix metal housing in position and abutment prior to attachment pick up and conversion to ISRPD.. 24

Figure 2.7 RPD prior to conversion and ISRPD after conversion 25

Figure 2.8 Intraoral occluasal images at 24 week follow up 26

Figure 2.9 Periapical radiographs at 24 week followup 26

Figure 3.1 Mean OHIP-49 severity scores at baseline (Visit 1), Visit 2 (week 6), Visit 3 (week 12), Visit 4 (week 18) and Visit 5 (week 24). Scores at Visits 2, 3, 4 and 5 were significantly lower than the mean score at Visit 1. The Visit 4 score was significantly lower than that at Visit 3 (P=0.032). 32

Figure 3.2 Mean OHIP-49 scores at Visits 1 to 5 plotted for five of the seven conceptual dimensions on which statistically significant reductions were observed at Visit 4 or Visit 5 relative to Visit 3. 33

1 INTRODUCTION

Partial edentulism is a clinical diagnosis that nearly all adults in the United States will experience, and many of these individuals will seek advice and treatment from their oral health care provider. For these patients, dentistry offers three major treatment options, which are removable partial dentures (RPDs), fixed partial dentures (FPDs), and implant supported crowns or fixed partial dentures. RPDs are often a highly requested treatment for a variety of reasons, but they have experienced a high rate of frustration among patients and dentists, particularly with mandibular distal free-end RPDs, referred to as Kennedy Class I or II RPDs. There are many dentists in the United States who have chosen to exclude RPD treatment from their practice due to perceived lack of benefit, lack of knowledge, or negative experience with this type of treatment. The purpose of this thesis is to demonstrate the effectiveness of RPD therapy when combined with implants as a treatment option and the subsequent impact of adjunctive, simplified implant therapy on the oral health quality of life of patients that elect to receive implant supported removable partial dentures (ISRPDs).

1.1 Partial edentulism and need for prosthodontic treatment

The number of partially edentulous patients in the United States will continue to rise as the population continues to grow and age, despite the falling number of teeth lost per individual. By the year 2030, the population of the United States older than 65 is expected to double.[1] Currently it is estimated that 50 million adults have a complete denture or RPD and

the number in expected to increase to 61 million by 2020. The percentage of individuals that require a complete denture is expected to decrease by 30 percent by the year 2030. This permits the assumption that most of these individuals will experience partial edentulism. The prevalence of complete edentulism for all adults in the United States has declined from 14.7 percent in 1970 to 7.5 percent in 1990. In the over 65 years age group, there has been a decline from 45.5 percent in 1970 to 37.6 percent in 1990. Tooth retention has also increased from an average of 23.1 teeth in 1970 to 25.1 teeth in 1990 for adults younger than 65, and for adults older than 65, tooth retention has improved drastically from 9.2 teeth in 1970 to 20.5 in 1990. On average, it is expected that an United States adult will retain 1.5 additional teeth per decade. As a result, the need for implants, fixed partial dentures, and/or removable partial dentures is predicted to increase in the near future.[2] Many of these patients present with a compromised dentition with no posterior tooth support that would permit treatment with a conventional fixed prosthesis, and frequently anatomic or financial considerations prevent implant supported fixed restorations.

The pattern of tooth loss that these patients experience often begins with the loss of posterior teeth. A cross-sectional national study "The National Survey of Oral Health in United States Employed adult population and seniors: 1985-1986" by the National Institute of Dental Research provided a glimpse into the oral health of our population. Not surprisingly, these data revealed that 1st and 2nd molars are the most commonly missing teeth, and that 40 percent of adults between the ages of 55-59 years had some form of free-end condition on the mandible. The working US adult, age 55-64 years, was also missing an average of 10 teeth.[3] Furthermore, 4.5% of adults ages 25-34 years and 10.0% of adults 35-

44 years had unilateral free-end edentulism. The age range of 45-54 years experienced a prevalence of mandibular free-end edentulism, both unilateral and bilateral, of 31.3%.[4]

To replace these teeth, current treatment usually consists of a RPD or implant-supported fixed prosthesis, but clinically, an implant-supported fixed prosthesis may not be indicated for many patients due to inadequate bone, inappropriate bone contours, and the need for grafting. In addition, patient's choose among their prosthetic options for a variety of reasons, including finances, length of treatment, and overall expectations. Removable partial dentures are often selected for removability, low cost, simplicity, and reduced treatment time. Patients refused conventional fixed treatment options due to hygiene, biologic cost to the adjacent teeth, and fear for their remaining dentition. This study also demonstrated that older patients with high oral health impact scores would also choose RPDs. Also within the context of this study, in evaluation of patients' treatment choices, the reasons that a RPD was rejected as a treatment option included the desire a fixed prosthesis, esthetics, individual teeth, unsatisfactory retention, and increased risk of biologic complications.[5]

1.2 Shortfalls of conventional removable partial denture therapy

The conventional removable treatment is the soft tissue-borne distal extension partial denture. Shortfalls in RPD therapy have been recognized and evaluated in the National Health and Nutrition Survey (NHANES III), which evaluated 1303 RPDs by calibrated dentists. Of these RPDs, two-thirds were determined to have at least one defect, with lack of stability being the most common. Mandibular RPD also had significant problems with retention.[6] From a patient satisfaction standpoint, while this treatment is mostly successful, 25% of patients experience problems with their removable prosthesis, and few improvements

had been made to this treatment modality to alleviate these complaints until the incorporation of the endosseous dental implant as a predictable treatment option. Particularly in first-time RPD users, most of the dissatisfaction was related to fit and chewing. This study also demonstrated that RPD classification, number of missing posterior teeth, and number of modification spaces do not influence patient satisfaction.[7] Yet another study concluded that mandibular distal extension RPDs required more adjustments and attributed to resorption of the mandible as result of pressure applied by the denture base. The authors also found that within 5 years approximately 25% of all RPDs had to be replaced or were not being worn. This number increased to 50% in 10 years.[8] One quarter of patients who receive this type of treatment are dissatisfied and two-thirds of RPDs have at least one defect represents serious shortcomings, and adjunctive or alternative treatment modalities must be explored. In other dental treatments, this clinical outcome is generally unacceptable. The incorporation of dental implants into RPD treatment will contribute additional rigid support in conjunction with the patient's remaining dentition and soft tissues to provide more distal support than conventional RPDs, resulting in a more stable and cost effective method for providing posterior support to the distal extension, permitting the simplification of treatment and enhancement of the patient's well-being.[9]

Efforts to improve treatment for Kennedy class I and II patients have been the subject of clinical studies for decades. Kapur, *et al* in the 1980s conducted a clinical trial comparing 115 patients receiving RPDs to 113 patients receiving FPDs supported by blade implants. This extensive clinical study into multiple clinical outcomes, including periodontal health, masticatory scores, and patient satisfaction, recognized shortcomings of RPD therapy. The author also indicated that patient satisfaction with implant supported fixed partial dentures

tends to be superior but stopped short of recommending this treatment in favor RPDs. In regard to patient satisfaction, the author found that RPDs had better oral hygiene but were limited by discomfort, restricted food choices, and inadequate retention. The RPD patients also indicated reduced ability to pronounce words correctly. Another important note in relation to this study is that 25 of the 115 RPD patients were excluded from comparison to the implant supported FPD due their treatment being judged a "failure."[10]

While most Kennedy Class I and II RPD patients are satisfied with their treatment, aspects critical to patient satisfaction with removable partial dentures often are related to retention, effective mastication, and comfort in the denture bearing area.[11] Previous research has shown that sources of dissatisfaction were related to mastication, esthetics, number of missing teeth and oral hygiene.[12] In conjunction, other research found that the distal extension partial denture is often the most infrequently worn partial denture following treatment and partial dentures frequently suffer from poor fit, resulting in tissue damage.[13] Yet another study cites the primary reasons of patient dissatisfaction as the lack of fit 76%, which caused problems with natural teeth 63%, and the need for adjustment 89%. This study also reported that the most common problems associated with RPD treatments are inflammation of the supporting gingival and alveolar ridge and tissue displacement.[14] As concluded by the previous studies, many of these patients experience a great deal of difficulty with their prosthesis, which requires constant attention from a treating dentist. While substantial resources have been allocated to the prostheses themselves, partial edentulism, particularly mandibular Kennedy Class I can have a substantial biological impact on the hard and soft tissues of the oral cavity.

Problems with distal extension partial denture treatment are not limited to patient dissatisfaction but also extend into the biological realm. Aquilino, *et al* compared treatment of 317 patients with no treatment, FPDs, and RPDs of bound posterior edentulous spaces over ten years. They determined failure as the extraction of one tooth adjacent to the edentulous space. This study found that 65 patients with FPDs had a 92% survival estimate for adjacent teeth. The 239 patients that elected no treatment had a survival estimate of 81%. Finally of 13 patients electing to receive RPDs 6 failed resulting in a 10 year survival estimate of 56%.[15]

Other biologic consequences extend beyond the dentition adjacent to the RPD. Distal extension partial denture designs rely on soft tissue for posterior support, which frequently results in posterior ridge resorption, a clinical observation of "combination syndrome" or "Kelly's syndrome." Other features noted with this clinical presentation are extrusion of lower anterior teeth, obliteration of the pre-maxilla, and "downgrowth" of the tuberosities. In addition, distal extension partial dentures have been implicated in tissue damage in the denture bearing areas, as well as, placing excessive force on the supporting abutment teeth.[1617] Patients with maxillary complete denture and mandibular Kennedy class I RPD are particularly susceptible, and this clinical presentation can become a pronounced and debilitating experience for these patients. Conventional removable prosthodontics has hypothesized that a stable upper denture provides for the tissue support at a resting position opposing a well supported stable mandibular RPD can reduce the severity and manage this clinical scenario. However, this recommendation requires vigilant and consistent maintenance to preserve the relationship of the tissues, residual dentition, prosthesis, and occlusion. By placing implants in the posterior edentulous spaces, this can aid in the support

of the mandibular prosthesis further mitigating the risk of combination syndrome by providing more stability to an otherwise dynamic scenario. This clinical presentation is rarely noted in patients that present with rigid posterior support of a mandibular prosthesis. It has been demonstrated that placement of implants will aid in the maintenance of bone as well as relieve the forces placed on the edentulous spaces.[18]

1.3 Current research with implant supported removable partial dentures

There is little scientific data documenting the effect of the ISRPDs on the oral health of patients receiving removable denture treatment beyond some case reports and even fewer clinical studies. However, this topic has gained increased attention within the last few years. To date, there have been three review articles written about the use of dental implants and RPDs. Each of the these articles, all written by international authors, from Israel and Italy, focus on treatment feasibility and clinical outcome of using implants in conjunction with RPDs to promote patient satisfaction and reduce the potential of undesirable prosthetic outcomes. All of the authors concluded that there is a critical need for clinical studies evaluating this treatment.[19] [20] [21] Therefore, the current practice of incorporating dental implants with a RPD offers no defined treatment criteria or manner by which to predict the most favorable outcome, despite it being a frequent treatment in private practice. In conjunction with the review articles, case reviews have been published in nearly every type of dental literature offering this as a treatment for patients in a variety of clinical scenarios. Each of these articles offer insight into the current use of dental implants with RPDs to solve the more common complaints associated with RPDs; stability, retention, and comfort, but without substantive clinical evidence for long term management of complex dental needs.

However, each of these articles do demonstrate the feasibly of using dental implants to increase patients overall satisfaction with careful treatment planning and clearly defined objectives. This study provides data on the successes or shortcomings in modifying current RPD treatment approaches by incorporating dental implants. All of these articles, both reviews and case reports, conclude that more research is required to further validate this treatment modality.

Currently, five articles have been published studying different aspects of RPD treatment with implants. The first of these is a retrospective clinical trial involving 10 patients with maxillary and mandibular distal edentulism. Implants in each of these patients were placed as distal as possible. In 5 of the patients, the implants were used as vertical stops only and in the other patients resilient retentive elements were used. A visual analog scale was used to evaluate patient satisfaction and clinical and radiographic exams were employed for clinical evaluation. The results of the study showed improved patient satisfaction, minimal prosthetic complications, and acceptable bone height around the implants. The most common prosthetic complication was loosening of the abutments. The authors also suggested that use of distal implants, will simplify RPD treatment by converting a Kennedy Class I to a Kennedy Class III treatment scenario and permits omitting the altered cast impression technique.[22]

The next publication was a study of 15 patients that presented with unfavorable conventional treatment prognosis with a follow up of 2-7 years. In each of these patients, implants were used in order to create a more favorable treatment scenario. The implants used in this study were greater than 10 mm in length and 3.7 mm diameter. The results included 100% implant success, with minor prosthetic complications, good chewing ability and

prosthetic stability. The author concluded that the use of dental implants should be used with conventional RPD theories to improve rest location, retention, and fulcrum positions. An emphasis was also placed on the reduced economic costs of treatment and simplified RPD design.[23]

Another retrospective study has also been published that included 23 partially edentulous patients. 13 of these patients received maxillary prosthesis and 10 received mandibular prosthesis. All Kennedy classifications were represented with maxillary class I and mandibular class II being the most prevalent. Implant survival was 95.5%. 87% of patients reported improved mastication; 78% cited improved esthetics; and 65% rated the prosthesis as very comfortable. The conclusion was that this treatment can be a predictable treatment modality, but that further prospective and long term clinical research should be conducted.[24]

Probably the most notable published retrospective study to date used extra-oral implants to support removable dentures with follow up of up to 8 years. While this study did not include RPDs or ISRPDs as treatments, it demonstrated the effectiveness of an unsplinted single implant in the posterior mandible to aid in support of the distal-extension prosthesis. In this study, 29 patients participated with 45 extraoral implants placed. Of these patients, only 6 had remaining natural roots or teeth. All of the other patients had interformaninal implants. The extra oral implants placed had a mean length of 3.25 mm and a cumulative survival rate of 97.4% at 2 years and 91.8% at 8 years. These implants were restored in all aspects including rests with no retention, ball anchors, magnets, and cast bars. Prosthetic complications were few and mostly limited to the abutments and retentive elements within the denture. The authors concluded that this treatment could prevent bone resorption in the

posterior mandible by maintaining bone around the implant and reducing the compressive load on the residual ridge. [25]

The last article to be discussed is a single blind prospective crossover designed pilot study of 5 patients evaluating masticatory movements, occlusal force and contact, and patient satisfaction. This study is by far the most controlled and objective research published to date. In these patients, no connection was made between the RPD and the implant. Healing abutments were used to create the ISRPD and healing caps were used to make the prosthesis a conventional RPD. Masticatory movements were recorded digitally, and no statistical differences were noted. Occlusal force was also recorded digitally using the T-scan system, and it was noted that the ISRPD had significantly greater force and contact than the conventional RPD. Finally, using a visual analog scale, the patient's satisfaction was significantly improved in all categories, which included stability, chewing, retention, and comfort. The conclusions of the article were consistent with the findings of the other ISRPD studies.[26]

Another topic often discussed is the best location for implant placement when the treatment plan calls for an ISRPD. One finite element analysis attempts to draw conclusions based on no treatment, no implant, an implant placed in second molar, an implant placed in the first molar, and an implant placed in the second bicuspid. The results indicated that placement of the implant in the second bicuspid reduced stress on the abutment teeth and offered more tooth support. Implant placement in the first molar area provided lower tendency for dislodgement, which means an increase in stability of the prosthesis. [27] Drawing from this conclusion, implant placement should be modified depending on the most

desired benefit of the treatment; support the remaining teeth or maximizing support of the ISRPD.

1.4 Oral Health Impact Profile

Several factors, previously discussed, have been implemented in patient satisfaction with their prosthesis, but ultimate goal of dental treatment is the improved oral health quality of life of the patient receiving care. An instrument for evaluating oral health quality of life is the Oral Health Impact Profile – 49. This is a 49 item questionnaire that assessed 7 theoretical subscales or dimension of the adverse oral health adapted by Locker from the 1980 World Health Organization International Classification of Impairments, Disabilities and Handicaps (ICIDH). The subscale categories are functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap.[28 29 30]

This is an instrument developed for the purpose of assessing social impact and outcome of treatment choice or research. While the OHIP-49 questionnaire was originally developed for cross-sectional analysis, many studies have used the questionnaire serially to assess the outcome of treatment. Recently, analysis was completed on the estimated change in OHIP-49 mean score change as the result of dental treatment to determine if there is a statistically significant outcome of dental treatment.[31]

1.5 Short dental implants

Another aspect of this clinical trial was the use of short implants to support the distal extension of the ISRPDs. In this particular case 6.0mm long by 4.0mm diameter dental implants were placed in each distal extension for additional retention and support of the

RPD. The use of shorter implants has been increasing due to improved surface technology and understanding of dental implants. These short dental implants can be indicated for many clinical situations, in which inadequate bone volume is present, the patient refused bone grafts, or many other possible scenarios. In recent years, several comprehensive articles have been published examining their clinical use. A review of current implant research completed by Renouard and Nisand examined the effects of implant length and diameter. This review included 53 implant studies, of which 13 were devoted to short implants and 21 studies provided data in regards to implant length. The authors noted higher failure rates in older studies, which involved machine surfaced implants placed in inferior bone and restricted anatomical sites. On the other hand, it was concluded that more recent studies have reported that short implants have survival rates similar to long implants. The protocol of this group of studies involved adaptation of surgical protocols to clinical presentation and incorporated roughened surface implants. However, the authors did conclude that further higher evidence research must be completed in order to fully understand the inter-relationship of implant length, implant diameter, bone quality and survival.[32] Another review, which was a meta-analysis, asked the question "is there a significant difference in survival between short (≤8 or <10mm) and conventional (≥10mm) rough-surface dental implants placed in 1) totally or 2) partially edentulous patients?" This meta-analysis included 37 articles and concluded that the use of short dental implants was as effective as longer conventional implants. This study divided the meta-analysis into two groups, one being implants in edentulous patients and other partial edentulous patients. The partially edentulous data included 12 studies with a survival of 97.06% (594/612) of implants ≤8mm in length. This is compared to a 98.33% (1,884/1,916) implants <10mm in length.[33] Other research not included in the previously

discussed meta-analysis further supports these findings. A retrospective clinical study evaluated the use of short dental implants restored with single crowns or fixed partial dentures and found that short dental implants (6-9mm) had similar cumulative survival rates as those for longer dental implants. This analysis evaluated 2,073 implants, which included 59 6mm implants in the posterior mandible, and demonstrated a cumulative survival rate of over 98% at 12-24 months.[34] Furthermore, another clinical literature review examined 745 short (less than 10mm) implants placed in the posterior mandible from 1998-2004 and found a survival rate of 98.9%.[35] Current research indicates that short implants can be successful and that the size of the implant in concert with the planned restoration should be a consideration when treatment planning, but should not be a single factor contra-indicating a potential treatment.

1.6 Aim of the study

Conventional RPD therapy has changed little in the past quarter century and few substantial changes in the standard of care have been developed. For a variety of reasons, both biologic and economic, some patients that seek dental care may not be candidates for implant supported fixed restorations. Currently, these patients have the options of no treatment, RPDs, or ISRPDs. Many of these patients choose a RPD, but major shortcomings of this treatment when used to replace missing posterior dentition include the absence of rigid posterior support and bone loss in the posterior mandible. To alleviate these problems, implants have been placed under RPDs to provide additional support, increase stability, and maintain bone in the posterior edentulous areas. This study will provide data about a treatment that would incorporate a minimally invasive procedure by using short dental

implants to enhance function and quality of life with distal free end RPds. An in depth analysis of these treatment options would provide better insight to treatment and expectations of both dentists and patients when considering treatment alternatives. The purpose of this research was to conduct a prospective consecutive controlled time series clinical study to evaluate: 1) the change in oral health by incorporating implants with RPD therapy, 2) evaluate prosthetic outcome of ISRPD, and 3) 1-year survival of 6mm Astra-tech implants in the posterior mandible

2 MATERIALS AND METHODS

This study was an open, prospective, time-series clinical trial to document implant survival rates and impact on the oral health quality of life of patients following the placement of 6mm Astra-tech implants in the posterior mandible of the partially edentulous patients who desire implants to aid in RPD function. The study population will consist of one group of patients, each receiving conventional RPD and ISRPD treatments. The research protocol was submitted to and approved by the Institutional Review Board of the University of North Carolina, Chapel Hill.

2.1 Patient Selection

All patients were recruited from within the School of Dentistry at the University of North Carolina. Patients that were planning to receive or had recently completed conventional RPD therapy were identified as potential candidates. Patients expressing interest in participating were appointed for a screening and provided informed consent prior to being enrolled.

2.2 Inclusion and Exclusion Criteria

The required inclusion criteria for patient enrollment are: 1) 18-85 years old, 2) ASA Class I or II, 3) no history of radiation in head or neck region, 4) non-smoker, 5) post-control phase of periodontal and restorative treatment, 6) at least 4 remaining teeth in the mandibular arch including 2 contra lateral cuspids and/or 1st bicuspids, 7) stable opposing dentition, 8) willing to have proper tooth preparations and/or recommended survey crowns fabricated to receive RPD, 9) minimum of 4mm interarch distance available for mandibular dentition 10) radiographic evaluation with panoramic x-ray (P-11) with >8mm of bone occlusal to inferior alveolar canal and >5mm wide crest of mandible without undercuts.

Patients who fulfill any of the following criteria will be excluded: 1) a history of radiotherapy in head and neck region, 2) smoke, 3) bone height less than 8 mm in posterior mandible, severe bone undercuts, 4) severe Angle's class II or III jaw relationship, 5) psychological problems for accepting a removable prosthesis (unwilling to wear partial dentures; severe gag reflex), 6) pregnant, 7) steroid use, 8) ASA Class III or IV patients, 9) uncontrolled diabetes, 10) known alcohol and/or drug abuse, 11) patients taking medication that might interfere with coagulation (e.g. Coumadin) and /or subjects with bleeding

disorders (e.g. liver disease), 12) unrealistic esthetic expectations, 13) any conditions that contraindicates dental implant therapy or elective dental therapy.

2.3 Prosthodontic and dental implant treatment

Visit 1 – Diagnosis and treatment planning

During this visit, patients were screened in order to select suitable patients to enroll in the study. After a complete explanation of the study, the patient was given the opportunity to read the consent form, have any questions answered, and sign the consent form. The screening process consisted of a clinical and radiographic assessment. All potential subjects underwent standard radiographic exam for screenings that consists of a full mouth radiographic series and P-11 panoramic x-ray. Medical and dental histories were taken, followed by extraoral and intraoral examinations.

Prosthodontic treatment planning followed guidelines suggested in McCracken's Removable Partial Denture text and included proper mouth preparations or survey crown fabrication.[36] Patients who desired ISRPD treatment were enrolled, and once the consent forms had been signed, patients were asked to answer an OHIP-49 questionnaire to establish a baseline oral health quality of life prior to initiation of treatment. Prior to patient dismissal, a treatment plan was signed and a preliminary impression was made of maxillary and mandibular dental arches along with edentulous areas for construction of radiographic/surgical guide, fabrication of custom trays, and development of partial denture design. The preliminary impressions were made using alginate (Dentsply) and stock trays, and casts were poured in microstone (Whipmix). A radiographic/surgical guide was fabricated using 2mm Biocryl thermoplastic material.

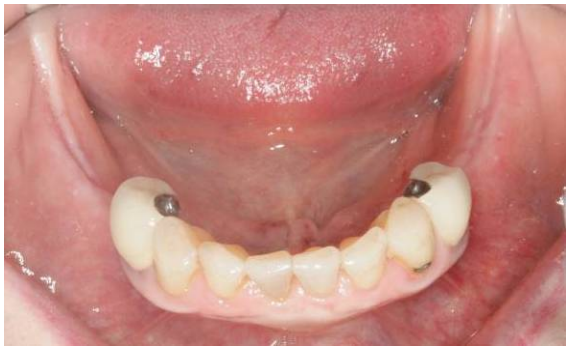

Figure 2.1 Kennedy Class I Mandible

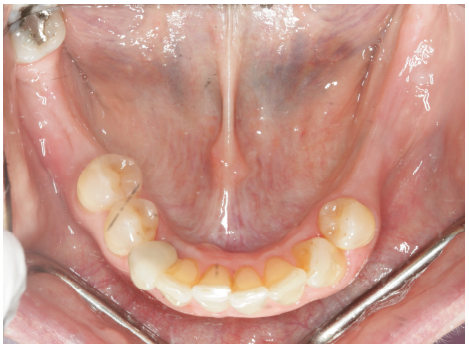

Figure 2.2 Kennedy Class II modification 1 mandible

Visit 2 – Survey with cone-beam tomography

The patient underwent a computerized cone beam tomographic (CBCT) survey using the Sirona Galieos CBCT machine with a radiographic/surgical guide in place. The surgical guide had radiopaque markers identifying potential implant sites. This procedure identifies the exact location of the inferior alveolar canal and the anatomical structure of hard tissues in the proposed site(s) of implant placement. CBCT survey is a standard radiographic examination performed before placement of an implant body in the posterior mandible.

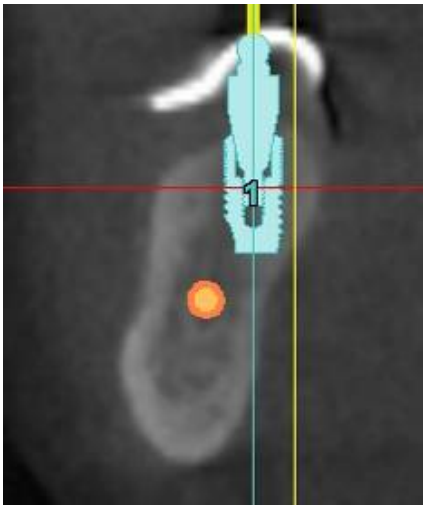

Figure 2.3 Cross sectional image from a CBCT

Visit 3 – Placement of implant body

Prior to implant surgery, patients were given 800mg Ibuprofen and 1 gram Amoxicillin (300 mg Clindamycin if the patient has penicillin allergy). Before surgery, patients rinsed with 0.12% chlorohexidine digluconate solution. A sterile drape covered patient's torso, head and neck region. Topical anesthetics was applied to oral mucosa in the posterior edentulous area and maintained for one minute. Infiltration anaesthesia using 5.4 to 7.2 mL of 2% lidocaine with epinephrine 1/100,000 was injected to the posterior mandible.

The proposed implant position was marked on the mucosa as indicated by the radiographic/surgical guide. In each patient, an implant was placed in each area for which a distal free end was present. A midcrestal incision was made by #15 scalpel blade and full thickness gingival flap was raised. Site preparation was accomplished using an electric motor with a maximum speed of 1500 rpm and external irrigation of sterile water. The preparation of the osteotomy for all implants used included use of the guide drill, which establishes the faciolingual and mesiodistal position of the implant. Care was taken throughout all site preparation to maintain proper angulation for prosthetic accessibility. The osteotomy was made sequentially through 2.0mm diameter drill, the 3.2mm diameter pilot drill. 3.2mm diameter drill, and 3.7mm diameter drill. A bone trap was used to preserve any autogenous bone for grafting any mini-treads possibly exposed after final placement of the implant body.

Using the electric handpiece at 20 rpm and 50 Ncm of torque without irrigation, the implant was placed level with the crest of bone. The implant was also examined to exclude lateral or axial implant movement. A cover screw was placed on the implant.

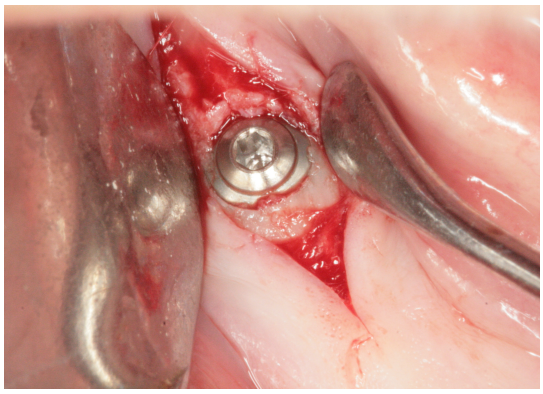

Figure 2.4 Implant body in position with cover screw

Grafting any micro-threads exposed after final placement of implant body was completed with autogenous bone from the bone trap. Primary closure of the mucosal flap was completed with 4.0 chromic gut sutures.

Finally, periapical and bitewing radiographs were obtained to verify implant location and baseline for bone level measurement. The patient was provided with antibiotics and 0.12% chlorohexidine digluconate solution rinse for one week following surgery as well as appropriate analgesic medications.

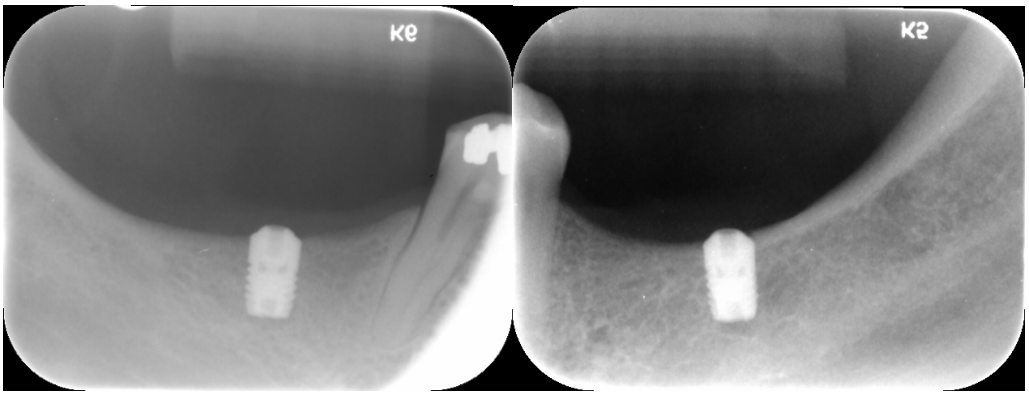

Figure 2.5 Periapical radiographs after implant placement

Visit 4 – Survey crown preparations (if required)

During this visit required tooth preparation(s) were completed for the fabrication of survey crown(s) as determined in the treatment plan.

Topical anesthetic was applied to oral mucosa in the posterior mandible and maintained for one minute. Inferior alveolar nerve block and local infiltration using 2% lidocaine with epinephrine 1/100,000 provided to provide anesthesia for mucosa and tooth/teeth to be prepared.

The tooth/teeth were prepared for porcelain-fused-to-metal survey crown (PFM), as designed during diagnostic phase of treatment, using dental handpieces and diamond burs. After completion of preparation an impression was made using Imprint III poly-vinyl siloxane heavy and medium body material (3M). A temporary crown was fabricated with Integrity bis-acryl temporization (Dentsply) material and luted with Temp-bond temporary cement. The PFM survey crowns were fabricated with high noble dental alloy using traditional laboratory fabrication techniques.

Visit 5 – Final impression for removable partial denture

During this visit the delivery of survey crowns, mouth preparations and final impressions were completed using conventional methods to obtain master casts for partial denture construction.

First, delivery of survey crowns was completed, if required.

Intra-enamel mouth preparations to receive RPD planned during diagnosis and treatment planning were prepared using dental handpieces and diamond burs. These preparations were then polished using brownie rubber polishing point.

Final impressions were made using stock trays or custom acrylic (Triad, Dentsply) trays made from preliminary casts. These trays were tried in and adjusted to hard and soft tissues. The impression was completed with Imprint III quick step heavy body and medium body

PVS material (3M), or the impression may also be made with alginate (Dentsply). The impression was poured in Jadestone (Whipmix). Stabilized record bases were fabricated to permit accurate mounting of casts on an articulator.

Visit 6 – Record maxillomandibular relationship

During this visit, the stabilized record base fabricated on the master cast was used to record a centric relation record. This record was made using Aluwax or Regisil (Dentsply) bite registration material.

Visit 7 – Framework try-in

In this appointment, the partial denture framework constructed with Vitallium (chrome-cobalt alloy) was tried in the patient's mouth to verify proper fit and construction. The partial denture framework was planned and cast in Vitallium using traditional dental laboratory techniques.

Visit 8 – Wax/tooth try-in

During this appointment a trial RPD was evaluated for esthetics, phonetics, centric relation, and function. The trial partial denture consisted of the cast partial denture framework, triad and/or baseplate wax trial denture base, and Ivoclar denture teeth. The wax RPD was placed in the patient's mouth. Vertical dimension of occlusion (VDO), phonetics, and esthetics of the denture was reevaluated and any modifications were made at this stage. The patient was given the opportunity to observe and approve the final arrangement before denture processing.

Visit 9 – Delivery of conventional removable partial denture

For delivery of the partial denture, pressure indicator paste was applied onto intaglio surfaces of the RPD. The denture was placed into the patient's mouth to locate pressure spots. Any pressure spots, overextended denture flanges, or sharp edges were relieved and polished. In addition, occlusion was verified and adjusted by guiding the patient into a centric relation or centric occlusion position and any identifiable errors were corrected. The patient was instructed in use and home care of the RPD.

Visit 10 – 1 week follow up

This visit was a recall after the delivery of the removable partial denture. An intraoral examination was performed and adjustments to the RPD were made, as required.

Visit 11 – 6 week follow up

During this visit patients were asked to complete OHIP-49 questionnaire, and an intraoral examination was performed and adjustments to the RPD were made, as required.

Visit 12 – 3 month follow up of RPD treatment, uncover of implant, and conversion of RPD to ISRPD

During this visit patients were asked to complete OHIP-49 questionnaire, and an intraoral examination was performed and adjustments to the RPD were made, as required. The surgical procedure to uncover the dental implant and place the attachment began with the application of topical anesthetics to oral mucosa in the posterior edentulous area and

maintained for one minute. Infiltration anesthesia using 2% lidocaine with epinephrine 1/100,000 was provided to posterior mandible. Approximately, 0.9 to 1.8 cc was used. The location of the implant was palpated and a #15 surgical blade was used to make a 4-5mm incision to expose the cover screw. The cover screw was removed and replaced with a ball abutment. 4.0 chromic gut sutures were used to reapproximate tissues, if required. The ball abutment was be torqued to 25 Ncm using an AstraTech torque wrench. The tissue surface of the RPD was relieved to provide space for a Clix attachment housing. Black spacer was placed on the ball abutment and a female Clix attachment was attached to the ball abutment. After verifying sufficient space between the Clix attachment and the denture base with disclosing wax, the Clix attachment was picked up intraorally using light cure Triad Gel (Dentsply). After the material cured completely, the ISRPD was removed from patient's mouth and excess material was removed. The ISRPD was polished and returned to the patient.

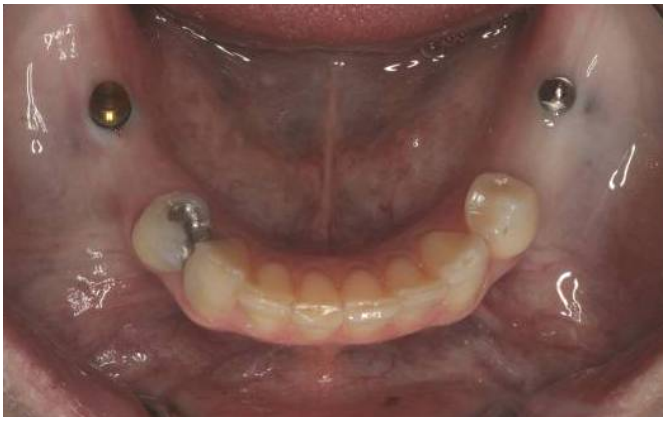

Figure 2.6 Immediately following abutment placement. Clix metal housing in position and abutment prior to attachment pick up and conversion to ISRPD.

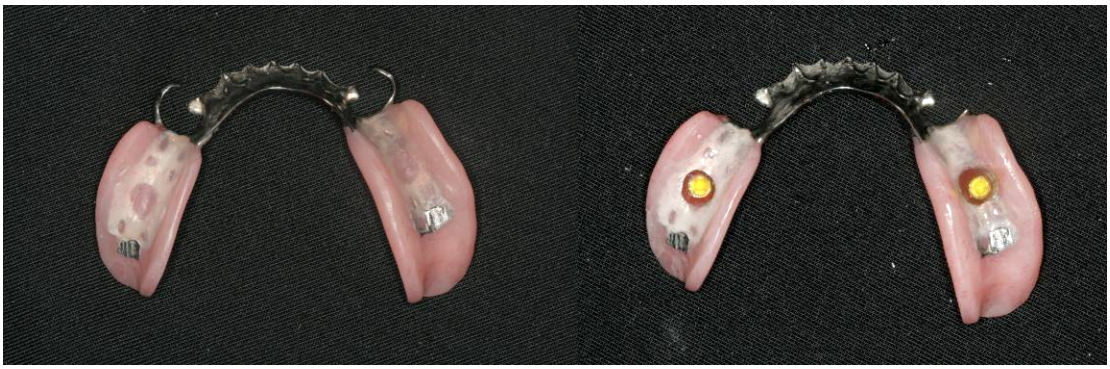

Figure 2.7 RPD prior to conversion and ISRPD after conversion

Visit 13 – 1 week follow up

This visit was a recall after pick up of the Clix attachments. An intraoral examination was performed and adjustments to the ISRPD were made, as required.

Visits 14, 15 – 6 week, 3 month follow up

Patients returned for follow-up visits at 6 week and 3 months after pick up of Clix attachments. An oral examination evaluating status of soft tissue, implant stability and treatment related complications were performed at all follow-up visits. Furthermore, peri-apical and bitewing radiographs of implants were taken to compare bone levels. Clinical photographs were obtained. At these visits, the patients also completed the OHIP-49 questionnaire.

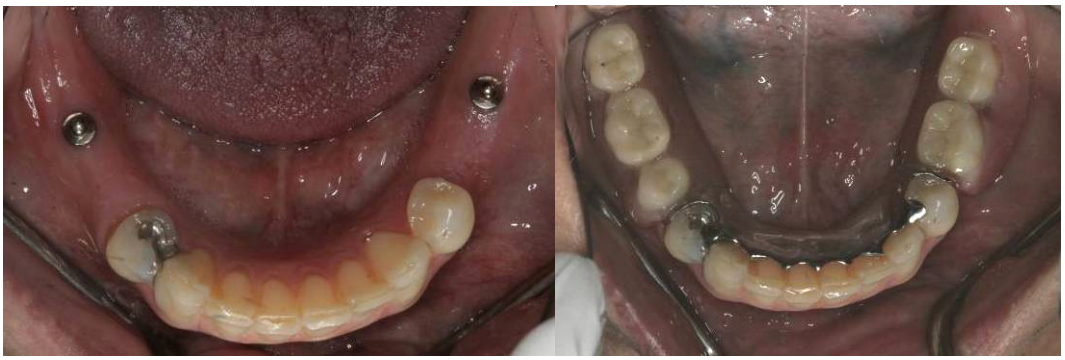

Figure 2.8 Intraoral occlusal images at 24 week follow up

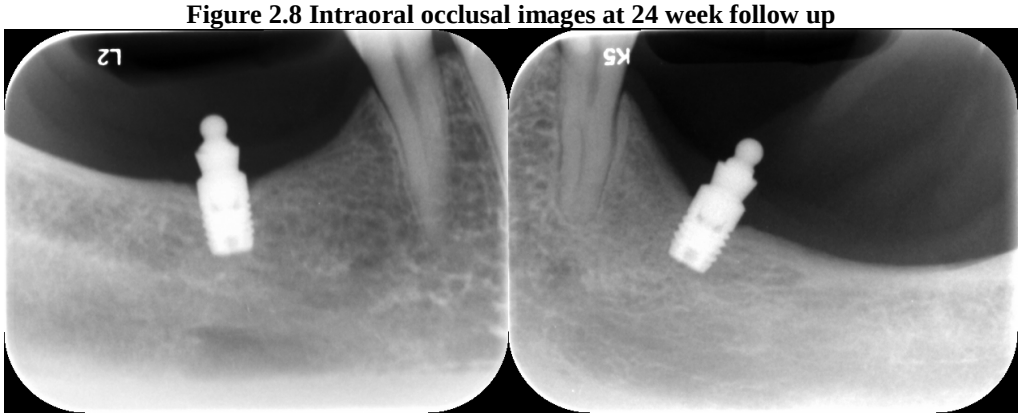

Figure 2.9 Periapical radiographs at 24 week followup

2.4 Measurement of outcomes

The primary outcomes for this study are:

1) Oral health related quality of life was evaluated by the OHIP-49 questionnaire. This is a 49 item questionnaire that assessed 7 subscales or aspects of oral health adapted by Locker from the 1980 World Health Organization International Classification of Impairments, Disabilities and Handicaps (ICIDH). The subscale categories are functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap. Each of the 49 questions was prefixed with the words, "Because of problems with your teeth, denture, or mouth have you…" For example, a question that assessed functional impairment asked, "had difficulty chewing any foods?" whereas a questions that assessed pain asked "… had painful aching in your mouth?" The reference interval was time since the last visit. Response to all questions was made using a

five-point ordinal scale ranging from “never” (coded 0) to “very often” (coded 4). (Appendix A)[37]

2) Prosthetic complications experienced in the cohort of patients. Such incidents as fracture, abutment loosening, repair, and reline as recorded and tabulated from a chart review of patients participating in this research.

3) Implant survival of Astra-tech 4.0mm diameter, 6mm in length implants in the posterior mandible. If the implant was in place and stable without pain or infection during follow up, it was considered surviving. Peri-apical radiographs were ordered at the time of implant placement, 6 weeks, and 12 weeks after abutment connection to monitor bone levels.

2.5 Statistical analysis

The dependent variable was the OHIP-49 severity score computed as the sum of ordinal responses across all 49 questions. This continuous variable has a possible range from zero to 196. Higher scores denote more frequent adverse impacts, and hence worse oral health quality of life. Any missing value was replaced with the sample mean computed from non-missing responses to the relevant OHIP item. In addition to the overall OHIP-49 severity score, the effect of treatment delivery was examined on the sum score of each of the seven OHIP-49 dimensions.

The OHIP-49 questionnaire was administered at baseline (week 0) and again at four subsequent visits at weeks 6, 12, 18 and 24 to test the study hypothesis that treatment delivery would improve patient oral health quality of life. This serial administration of OHIP-49 was timed to assess patient outcomes at critical treatment phases. Follow-up at 6 and 12 weeks assessed the impact of the conventional RPD on oral health quality of life. The week

18 evaluation assessed the impact of conversion to a ISRPD. Final assessment of the stable environment was conducted at week 24, six months after initiation of treatment. Each administration of the OHIP-49 is referred to in this study as a "visit".

Group differences in mean OHIP-49 severity scores at baseline were tested using the student t-test or ANOVA. To compare patient scores against OHIP norms for the United States population, a summary score was computed limited to the seven OHIP items contained in the NHANES-OHIP. These seven items are questions 6, 10, 16, 20, 28, 43, and 47 of the OHIP-49.

Analyzing data with serial measurements on the same patient requires a different methodology from the ordinary least squares regression. This is because measurements of any one patient at multiple time points are likely to be correlated and cannot be considered as independent observations. To capture this correlation, models estimated covariance parameters. A series of two-level fixed slope, random intercept variance components models was fitted using maximum likelihood estimation with the *xtmixed* command in STATA version 10.1 SE statistical software (Stata Corporation, Texas). The mixed-effects linear regression models estimated the effect of treatment on patients' oral health quality of life measured serially at five end-points over the treatment period. First, the null model was fitted to estimate the intraclass correlation coefficient, which indicates the extent of variance within patients. The second model additionally estimated the effect of visit and the final model adjusted for covariates. Beta coefficients are directly interpretable as mean OHIP-49 severity score. Coefficients prefixed with a minus symbol indicate a reduction in OHIP-49 scores relative to the referent category.

3 RESULTS

3.1 Oral Health Impact Profile (OHIP-49)

Results are presented for ten healthy patients (4 males and 6 females) with complete data. Patients were aged from 51 to 71 years at baseline (mean 59.2) and eight self-identified as white race. On average, patients had retained 8.6 natural mandibular teeth (range 6 to 11) and had an average of 4.2 teeth on their RPD (range 2 to 8). Prior to enrollment in the study, eight patients had experience wearing prostheses.

Table 3.1 Selected Characteristics of Study Participants and Mean (s.e.) OHIP-49 Severity Score at Baseline (n=10)

	N	Mean (s.e.) OHIP-49 score at baseline
All patients	10	63.9 (8.6)
Gender		
Male	4	68.3 (14.8)
Female	6	61.0 (11.3)
Age		
<60 years	6	75.0 (10.0)
≥60 years	4	47.3 (12.0)
Experience with prostheses		
Prior experience	8	64.8 (10.1)
No prior experience	2	60.5 (20.5)
Opposing arch		
Natural teeth	3	50.7 (13.8)
Removable partial denture	4	70.3 (13.0)
Denture	3	68.7 (21.1)
Removable partial denture design		
Kennedy Class 1	6	57.5 (12.0)
Kennedy Class II, mod 1	4	73.5 (11.8)
Implant and graft		
1 implant, 0 graft	3	66.3 (13.2)
1 implant, 1 graft	1	95.0 (0.0)
2 implants, 0 grafts	5	62.2 (13.5)
2 implants, 1 graft	1	34.0 (0.0)
N retained mandibular teeth		
6-8 teeth	5	67.0 (13.0)
9-11 teeth	5	60.8 (12.5)
N teeth on partial denture		
2-4 teeth	6	67.7 (12.3)
5-8 teeth	4	58.3 (12.5)

Wide variability between patients was observed in baseline OHIP-49 severity score with scores ranging from 27 (infrequent impacts) to 102 (frequent impacts). The mean OHIP-49 severity score was 63.9 (95% confidence interval = 44.5 to 83.3). At baseline all 10 patients reported at least one impact had affected them “fairly often” and seven patients reported one or impacts “very often”. Those patients aged 60 years or older and those with only natural teeth in the opposing arch tended to report lower OHIP-49 scores than younger patients and those with a maxillary denture, however no between-group differences reached the conventional threshold for statistical significance of P<0.05 (Table 3.1).

Table 3.2 Difference in mean OHIP-49 severity scores at Visits 2-5 relative to Visit 1baseline levels (n=10)

	Beta coefficient	95% CI	P value
Visit 1	Ref		
Visit 2	-25.3	-38.1, -12.5	<0.001
Visit 3	-24.2	-37.0, -11.4	<0.001
Visit 4	-38.2	-51.0, -25.4	<0.001
Visit 5	-43.4	-56.2, -30.6	<0.001
constant	63.9	48.9, 78.0	<0.001

In the null mixed model, the intraclass correlation coefficient was 0.340. This indicates that 34% of the variance in OHIP-49 severity scores was attributed to correlation within patients (not tabulated). The categorical variable “Visit” was additionally fitted in the model with Visit 1 nominated as the referent category. Substantial and statistically significant reductions in mean OHIP-49 severity scores were observed at each of Visits 2 through 5 relative to Visit 1 scores (Table 3.2).

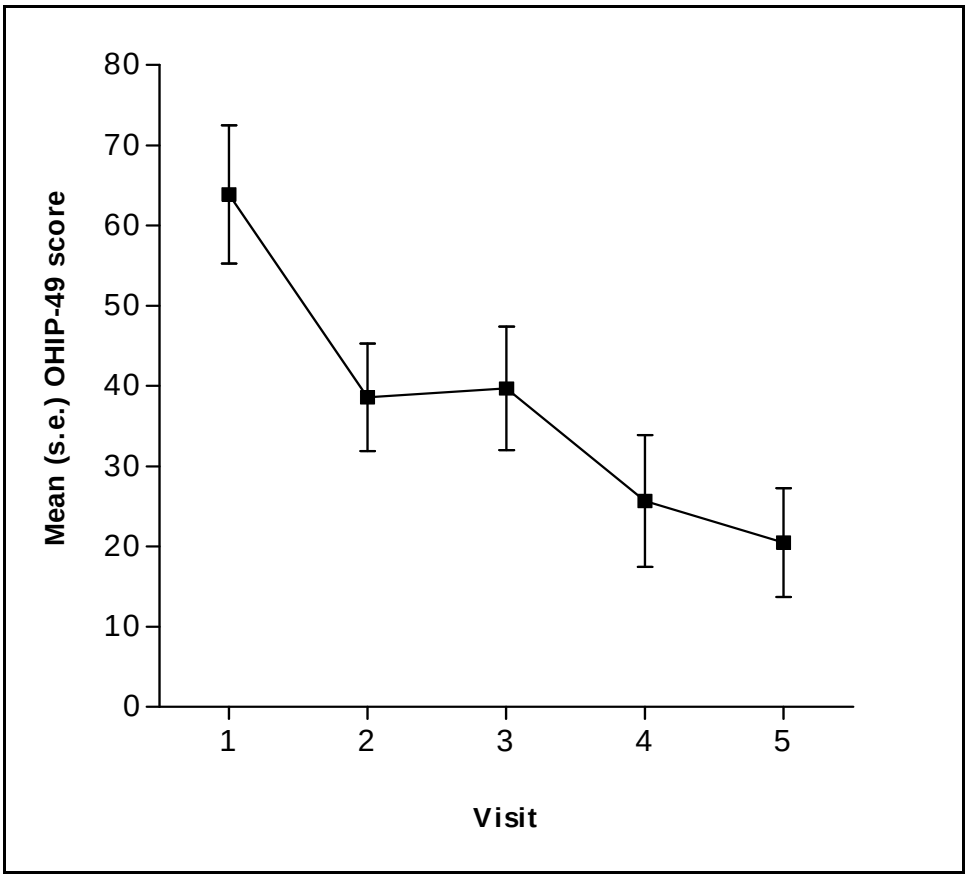

Figure 3.1 Mean OHIP-49 severity scores at baseline (Visit 1), Visit 2 (week 6), Visit 3 (week 12), Visit 4 (week 18) and Visit 5 (week 24). Scores at Visits 2, 3, 4 and 5 were significantly lower than the mean score at Visit 1. The Visit 4 score was significantly lower than that at Visit 3 (P=0.032).

Table 3.3 Difference in mean OHIP-49 severity scores at Visits 1,2, 4 and 5 relative to Visit 3 levels (n=10)

	Beta coefficient	95% CI	P value
Visit 1	24.2	11.4, 37.0	<0.001
Visit 2	-1.1	-13.9, 11.7	0.866
Visit 3	Ref		
Visit 4	-14.0	-26.8, -1.2	0.032
Visit 5	-19.2	-32.0, -6.4	0.003
constant	39.7	25.6, 53.8	<0.001

A greater than three-fold reduction in mean OHIP-49 severity scores was observed over the 24 weeks treatment period. Scores reduced 43.4 units per patient on average; from 63.9 at baseline to 20.5 at Visit 5 (Figure 3.1). Greatest effect was recorded at Visit 2 where OHIP-49 scores reduced significantly by 25.3 units per patient on average. A second notable treatment effect was at Visit 4 where mean OHIP-49 scores reduced significantly by 14.0 OHIP-49 units on average from Visit 3 levels (Table 3.3). Further slight gains were observed at Visit 5 relative to Visit 4, but these were non-significant.

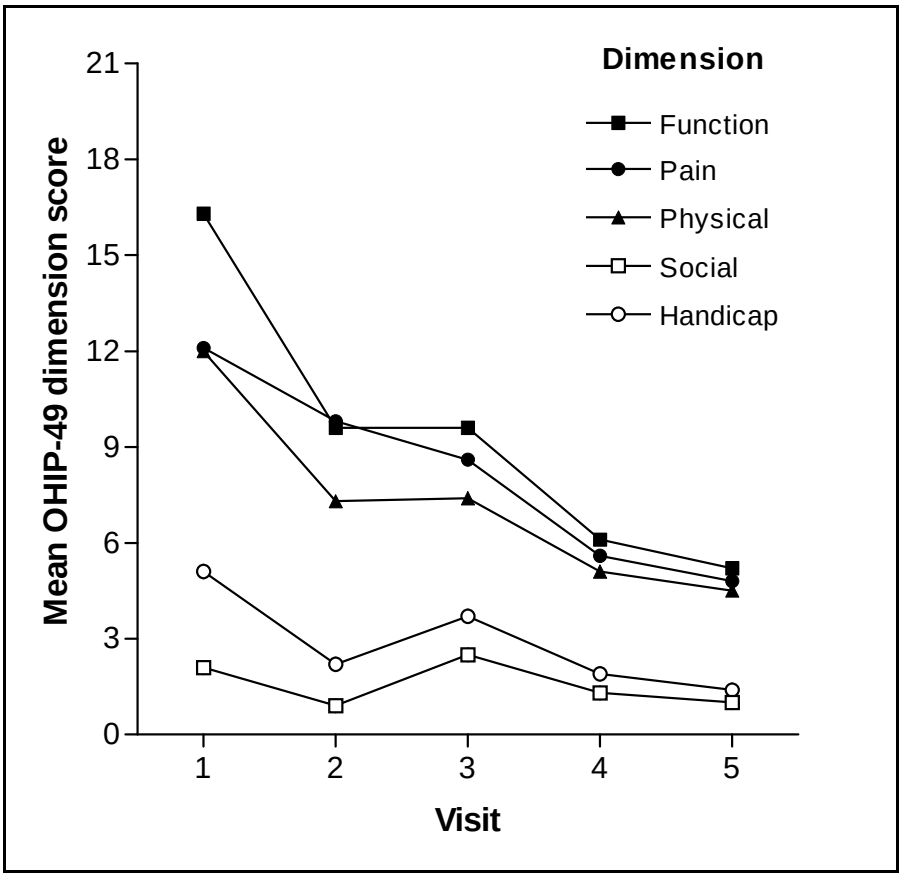

Figure 3.2 Mean OHIP-49 scores at Visits 1 to 5 plotted for five of the seven conceptual dimensions on which statistically significant reductions were observed at Visit 4 or Visit 5 relative to Visit 3.

Examination of the treatment effect at Visits 4 and 5, revealed significant improvement in patients' oral health quality of life on five of the seven OHIP-49 dimensions from Visit 3 levels. Specifically, at Visit 4 and/or Visit 5 patients reported less functional limitation, pain, physical disability, social restriction and handicap (Figure 3.2). Improvements in psychological discomfort and psychological disability failed to reach statistically significance at Visits 4 or 5 relative to Visit 3.

The baseline mean NHANES-OHIP score, derived from the seven OHIP questions used in NHANES, was 11.6 (s.e.=1.3). This value is elevated four-fold over the national estimate for 2003-2004 (mean = 2.8) for NHANES study participants. [38] At Visit 5 the mean NHANES-OHIP value had decreased to 4.0 (s.e.=1.3).

3.2 Prosthetic Complications

Prosthetic complications did occur during this research and were primarily minor and could be handled within a single clinical visit. The occurrence of these clinical complications are summarized, but were primarily limited to post delivery denture base adjustments to improve patient comfort. Abutment loosening was rare and the need for relines of the intaglio surface of dentures base was limited (Table 3.4).

Table 3.4 Prosthetic complications encountered during treatment with RPDs and ISRPDs

Prosthetic Complication	Number	Percentage of Patients
Denture Adjustment	13	90%
Clasp Adjustment	3	30%
Reline of Denture Base	1	10%
Reprocess of RPD	1	10%

Implant Complication	Number	Percentage of Implants
Abutment Loosening	1	6.25%
Reinsertion of attachment	1	6.25%

3.3 Implant Survival

All 16 implants placed in all 10 patients remained functional without pain, infection, or mobility through 6 months of follow up. The implant survival was 100%

4 DISCUSSION

This open prospective time series clinical trial used the 49-item Oral Health Impact Profile (OHIP-49) to evaluate the prosthodontic therapy of ten patients. The OHIP-49 is the most widely used instrument to evaluate oral health quality of life from the patient's perspective. The results support conclusions drawn by previously mentioned studies and case reports that evaluated patients' satisfaction with their prosthesis, however the discussion in these studies was directed at the technical and clinical aspects of delivery of care, particularly implant survival and prosthetic complications. What has been demonstrated by the results, despite the very short follow up times, is that incorporation of dental implants makes a positive and significant improvement on the patient's oral health related quality of life, which is the primary goal in prosthodontic treatment. Five of the seven theoretical subscale dimensions: functional limitation; physical pain; physical disability; social disability; and handicap all demonstrated statistical improvements from RPD to ISRPD with an overall mean reduction of 14 points at 18 weeks and 19 points at 24 week follow ups. These patients have indicated that they feel they are able to function better and are more comfortable with their treatment.

Johns, *et al* recently showed that prosthodontic treatment leads to improved scores on OHIP-49 questionnaire. To make this relationship, the OHIP-49 scores from before and after treatment where related to post-treatment global transition questions. Through statistical analysis, the authors determined that an improvement of 6 OHIP units in the total score is

related to “little improvement” and an improvement of 10 OHIP units was related to “a lot better” global transition response.[39] Using this scale, relating the data collected during this research, this treatment is both clinically and statistically significant.

When the results are further analyzed and the seven questions that are included in the NHANES-OHIP were isolated, this group of patients had significantly lower oral health quality of life that the U.S. general population at the initiation of treatment. However, at the completion of the follow ups, these patients had a similar oral health quality of life, which is very important finding relating to this treatment.

The patient’s experience in this research mirrored the findings in a Japanese study that examined the impact of oral health between low quality RPDs and high quality RPDs. In this Japanese study, patients that had a low quality RPD had a mean OHIP-49J score of 51.6 and high quality RPD had a mean OHIP-49J score of 42.5, which approximated the score in this study of 39.7 at the 12 week follow up (visit 3) of RPD treatment just prior to conversion to ISRPD.[40] By incorporating the dental implant into the treatment of these patients further improvement in the OHIP-49 score provides for an expectation of a better outcome for these patients without extensive surgical procedures, such as grafting to place multiple implants or the expense associated with fixed implant supported restorations.

While this treatment offers the possibility of simplified treatment planning and surgical procedures, meticulous treatment planning should be executed in order to avoid future treatment issues. Implants should be planned and positioned for future use should a patient decided to pursue fixed implant supported restorations. In this study, the implants were placed in the first or second molar positions in an effort to prevent the ISRPD from becoming a terminal prosthetic treatment. In a sense, use of the ISRPD is a cost effective

treatment for improvement from RPD and is a treatment for the titration of therapy in which resources, either biologic or economic, are limited.

While the treatment provided during this study improved the oral health quality of life of the patients, some complications did occur. These complications were generally easily managed during first one or two post delivery follow up visits. Patient discomfort was the most common prosthetic complication that required denture base adjustments. Other complications included the need to adjust retentive clasps, which where also managed during follow up appointments. Abutment loosening did occur once during the follow up period, which required the attachment to be picked up again. One patient required a reline of the denture base prior to delivery to ensure RPD stability and create a proper relationship of the denture base, tissue, and remaining dentition. The remaining complication was incidental and related to accidental damage to the prosthesis by the patient.

The implant survival after 6 months was 100%, but since prosthetic implant failure occurs most often within the first year following restoration this length of time for observations is insufficient to draw any conclusions. Non standardized peri-apical radiographs were taken during follow up visits to monitor bone levels, but this does not permit precise measurement of bone levels. One year data would result in a more meaningful discussion, but would still be insufficient to draw any long term conclusion. This is a common weakness of dental research regarding dental implants survival or success. The results of this study, while demonstrating the effectiveness of ISRPD treatment, provides limited support for the use of 6mm Astra-tech implants in the posterior mandible for an ISRPD due to inadequate length of follow up.

Weakness of this clinical study design must also be discussed. The first of these is use the time-series design. A cross-over study design would have permitted a more definitive assessment of the treatment modality by compensating for patient expectations of the treatment. Another aspect was that the RPD had to permit use of the framework for both and RPD and ISRPD, thus hampering optimal ISRPD design. Also this study did not collect any objective clinical data in regards to function, mastication, bite force, or other manner of data collection.

5 CONCLUSION

Within the limitations of this study,

1. ISRPDs improved the oral health quality of life of mandibular Kennedy Class I and Kennedy Class II patients.

2. The ISRPD is a treatment option that should be considered, along with RPD and implant supported fixed crowns or partial dentures, when treatment planning Kennedy Class I and II patients.

3. 6mm Astra-tech implants can be used to support ISRPD, but with caution due to inadequate long-term follow up.

4. Prosthetic complications of ISRPD are minimal and similar to complications of RPDs.

Appendix A

Because of problems with your teeth, denture, or mouth have you….
(Oral Health Impact Profile-49)

1. Have you had difficulty chewing any foods because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
2. Have you had trouble pronouncing any words because of problems with your teeth, mouth, or dentures	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
3. Have you noticed a tooth which doesn't look right?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
4. Have you felt that your appearance has been affected because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
5. Have you felt that your breath has been stale because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
6. Have you felt that your sense of taste has worsened because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
7. Have you had food catching in your teeth or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
8. Have you felt that your digestion has worsened because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
9. Have you felt that your dentures have not been fitting properly?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
10. Have you had painful aching in your mouth?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
11. Have you had a sore jaw?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
12. Have you had headaches because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
13. Have you had sensitive teeth, for example, due to hot or cold foods or drinks?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
14. Have you had tooth ache?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know

15. Have you had painful gums?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
16. Have you found it uncomfortable to eat any foods because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
17. Have you had sore spots in your mouth?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
18. Have you had uncomfortable dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
19. Have you been worried by dental problems?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
20. Have you been self conscious because of your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
21. Have dental problems made you miserable?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
22. Have you felt uncomfortable about the appearance of your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
23. Have you felt tense because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
24. Has your speech been unclear because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
25. Have people misunderstood some of your words because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
26. Have you felt that there has been less flavour in your food because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
27. Have you been unable to brush your teeth properly because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
28. Have you had to avoid eating some foods because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know

29. Has your diet been unsatisfactory because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
30. Have you been unable to eat with your dentures because of problems with them?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
31. Have you avoided smiling because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
32. Have you had to interrupt meals because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
33. Has your sleep been interrupted because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
34. Have you been upset because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
35. Have you found it difficult to relax because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
36. Have you felt depressed because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
37. Has your concentration been affected because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
38. Have you been a bit embarrassed because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
39. Have you avoided going out because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
40. Have you been less tolerant of your spouse or family because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
41. Have you had trouble getting on with other people because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
42. Have you been a bit irritable with other people because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know

43. Have you had difficulty doing your usual jobs because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
44. Have you felt that your general health has worsened because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
45. Have you suffered any financial loss because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
46. Have you been unable to enjoy other people's company as much because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
47. Have you felt that life in general was less satisfying because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
48. Have you been totally unable to function because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know
49. Have you been totally unable to work to your full capacity because of problems with your teeth, mouth, or dentures?	☐0 Never or not applicable	☐1 Hardly ever	☐2 Occasionally	☐3 Fairly often	☐4 Very often	☐5 Don't know

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