Changes in Patient and FDP Profiles Following the Introduction of Osseointegrated Implant Dentistry in a Prosthodontic Practice

Terry R. Walton, BDS, MDSc, MS, FRACDS, FICD^a

Purpose: This paper describes the effects of implant-related dentistry on patient profiles and the types of fixed dental prostheses provided in clinical practice. Materials and Methods: All implant- and tooth-supported prostheses provided in a prosthodontic practice between 1984 and 2007 were tabulated. Incidence was analyzed in relation to gender, age at time of prostheses insertion, and prostheses type. Results: Tooth-supported single crowns (TSCs) and tooth-supported fixed dental prostheses (TFDPs) were involved in 97% of treatments requiring fixed dental prostheses from 1984 to 1991. From 1991 to 2007, however, a marked increase in the number of implants restored directly corresponded with a decrease in the number of TFDPs so that by 2007, implant-supported fixed dental prostheses (IFDPs) accounted for 81% of all tooth replacements. Between 1984 and 2007 the incidence of TFDPs was 61% in females and 39% in males, whereas the incidence of IFDPs was 55% in females and 45% in males. IFDPs were also involved in 35% of restorations in patients under 31 years of age and TFDPs in 19%. In the under-21 years age group, IFDPs were more common in females (9%) than males (4%), but in the 21 to 30 years age group they were more common in males (21%) than females (13%). There was a decrease in three-unit TFDPs, in TFDPs with four or more pontics and those not satisfying Ante's Law, and in teeth used that had been subjectively assessed to have an unfavorable 10-year prognosis at the time of prosthesis insertion. **Conclusions:** The incorporation of osseointegrated implant dentistry into a clinical practice has resulted in changes in the patient profile and type of fixed dental prostheses provided, including a decrease in the use of TFDPs; an increase in the referral of patients under 31 years of age; a decrease in three-unit, long-span, and complex TFDPs; and a decrease in tooth abutments assessed to be structurally or biologically compromised. Int J Prosthodont 2009;22:127-135

The development of osseointegration has had a profound impact on the practice of dentistry. The original articles describing the science, clinical protocols, and outcome developed by Brånemark et al and Adell et al introduced enhanced rigor into the evaluation of new techniques and materials.^{1.2} Although initially applied to the fully edentulous dentition, by the

early 1990s osseointegrated implant support for single tooth³ and partially edentulous^{4,5} replacement had been accepted. This has provided expanded and alternative treatment options to conventional fixed tooth-supported prostheses.

Implant dentistry currently commands the greatest effort in scientific investigation and receives the bulk of financial support for research compared to any other facet of dentistry. Traditional paradigms have been challenged and heroic efforts to save teeth are no longer considered appropriate. Questions concerning the viability of maintaining root-filled teeth and those with questionable long-term prognoses are being debated. On the other hand, the myriad of hardware components involved in implant dentistry has attracted many commercial companies and their

^aClinical Associate Professor, Faculty of Dentistry, University of Sydney, Sydney, Australia; Private Practice, Sydney, Australia.

Correspondence to: Dr Terry R. Walton, Suite 5 The Vintage, 281-287 Sussex Street, Sydney NSW 2000, Australia. Fax: 61-2-92650999. Email: twalton@mail.usyd.edu.au

involvement and promotion has resulted in a change in the educational avenues traditionally responsible for education at both undergraduate and graduate levels. This has led to debate concerning the current rigor and discipline applied to the science underpinning implant dentistry.

Given a choice, most patients prefer a fixed prosthesis for single or multiple tooth replacements. However, in many patients, the available tooth abutments themselves are structurally impaired or have compromised support as a consequence of caries or periodontal disease. With the incorporation of implantsupported prostheses, fixed replacements can be provided without relying on at-risk teeth. In addition, implant placement can effectively reduce edentulous span length so that even structurally sound teeth are not compromised by being used as fixed dental prosthesis (FDP) abutments in long-span situations.

Although partial coverage retainers have been used, full coverage retainers with ceramic or metal-ceramic technology are preferred. The replacement of one tooth will often command a high biologic price with the removal of much sound, adjacent abutment tooth structure. Biologically conservative implant-supported crowns are an alternative to single tooth replacement when abutment teeth are relatively intact and the alternative, although biologically conservative, removable partial denture can be avoided.

The author has been in practice as a specialist prosthodontist since 1984. This timeline has straddled a period before and after the introduction of osseointegrated implant dentistry, and has provided a unique opportunity to assess the effects of one of the most profound changes experienced in clinical dentistry: How the incorporation of implant-supported prosthodontics has influenced the clinical patient profile and the type, incidence, and outcome of tooth-supported prostheses provided. This paper documents these changes and a following paper will test the hypothesis that the incorporation of osseointegrated implant dentistry has resulted in an improvement in the outcome of tooth-supported prostheses.

Materials and Methods

All implant- and tooth-supported prostheses provided in clinical practice between 1984 and 2007 were tabulated. Incidence was analyzed in relation to gender, age at time of prosthesis insertion, and prosthesis type. Age was grouped for analysis in 5-year periods.

Differences in the incidence, type of prosthesis, abutments used, and teeth replaced were compared. Any adjacent implant crowns were splinted and classified as an implant-supported FDP.

Data reported include changes in the following:

- Number of tooth-supported fixed dental prostheses (TFDPs) and tooth-supported single crowns (TSCs)
- Number of implant-supported fixed dental prostheses (IFDPs), including single crowns (ISCs), full implant-supported fixed dental prostheses (FIFDPs), and partial implant-supported fixed dental prostheses (PIFDPs)
- Use of tooth abutments deemed to have an unfavorable 10-year prognosis (ie, compromised structural integrity or periodontal support) at prosthesis insertion
- · Provision of three-unit TFDPs
- Provision of TFDPs that had four or more pontics and those that did not satisfy Ante's Law

Several of these factors, which have been graphically documented, were grouped in 5-year periods to even out single year variations due to the pattern of referrals to the practice. In addition, given that the years 1984 to 1987 involved the establishment of the practice referral base and output, it was considered that valid comparisons could only be made from 1988 onward.

Results

Incidence of Tooth- and Implant-Supported Prostheses

There were 1,729 treatment episodes (TEs) for 1,165 patients involving tooth- and implant-supported fixed prostheses between 1984 and 2007. Five hundred sixtyfour patients had more than one TE (range: 2 to 11). More than one prosthesis type was provided in 229 TEs.

Tooth-supported prostheses were provided in 97% of TEs from 1984 to 1991. A marked increase in the use of osseointegrated implants was evident from 1991 to 2007 (Fig 1), accounting for 81% of all tooth-replacement prostheses in 2007. The reduction in implants restored in 2005 was due to a single-year variation in the reasons patients were referred to the practice, rather than the usual preferential acceptance of patients for specific prosthesis provision. Three hundred eighty-six IFDPs (182 ISCs, 150 PIFDPs, and 54 FIFDPs) supported by 913 implants were provided.

The number of TFDPs (n = 749) provided each year decreased markedly from a maximum of 55 in 1989 to only 8 in 2007, while the numbers of TSCs (n = 2,678) remained relatively static over the time period (Fig 2).

Gender and Age

Of the 2,678 TSCs provided, 69% were in females. Of the combined tooth- and implant-supported tooth replacement prostheses, 56% (n = 1,135) were in females. The trend toward a decrease in TFDPs as the number



Fig 2 Tooth-supported single crowns (TSCs), tooth-supported FDPs (TFDPs), and implant-supported FDPs (IFDPs) (including ISCs) from 1984 to 2007.

1984 and 2007 (n = 913).



of IFDPs rose was consistent for both genders. The incidence of TFDPs in females and males was 61% and 39%, respectively, while the incidence of IFDPs was 55% and 45%.

Patients under 31 years of age were provided with a higher percentage of IFDPs (35%) than TFDPs (19%). A higher percentage of females (9%) than males (4%) received IFDPs in the under-21 age group; a higher percentage of males (21%) than females (13%) received IFDPs in the 21 to 30 age group. The youngest female patient receiving an IFDP was 15 years old, while the youngest male patient was 18 years old (Figs 3a and 3b).

Abutments and Teeth Replaced Distribution

Maxillary canines (19%) and central incisors (14%) were the most common tooth-supported abutments for TFDPs, while mandibular incisors (2.5%) and first molars (1%) were the least common. Implants supporting single crowns were concentrated in the anterior maxilla (71%), while implants supporting prostheses were evenly spaced throughout each arch (Figs 4a and 4b). Implants supporting fixed complete dentures (n = 54)accounted for the high number of implants in the mandibular incisor region (11%), compared to abutments supporting TFDPs (2.5%).





25 TFDPs (n = 229) IFDPs (n = 149) 20 % of male patients 15 10 5 0 25-30 -31-35 21-25 36-40 41-45 54555155560 61-65-66-70-75-80 - 80 221 Age (y)



Maxillary canines (4%) and second molars (2%) were the least commonly replaced teeth (excluding third molars) for TFDPs, while mandibular first molars (12%) were the most common. Of the 1,369 teeth replaced with IFDPs, 13% were replaced with ISCs, 40% with PIFDPs, and 47% with FIFDPs. Teeth replaced by ISCs were concentrated in the anterior maxilla, while those replaced by a combination of FIFDPs and PIFDPs (excluding second and third molars) were evenly spread throughout each arch (Figs 5a and 5b).

Changes in TFDP Characteristics

An increase in ISCs from 1988 to 2007 coincided with a decrease in the provision of three-unit TFDPs (Fig 6), while an increase in IFDPs coincided with a decrease in the number of TFDPs containing four or more pontics, those that did not satisfy Ante's Law, and abutment teeth that were subjectively judged to have an unfavorable 10-year prognosis at the time of prosthesis insertion (Fig 7). Ninety percent of teeth judged to have an unfavorable 10-year prognosis because of compromised structural integrity (n = 185) were nonvital and 39% of those judged to have compromised periodontal support (n = 110) were nonvital.

Teeth with compromised periodontal support accounted for 48% (n = 166) of teeth restored during the period of 1984 to 2007 that had been judged to have an unfavorable 10-year prognosis. Similarly, compromised teeth accounted for only 24% (n = 129) of teeth with an unfavorable 10-year prognosis restored during the period of 1998 to 2007. These results are summarized in Table 1.



Fig 4b Position of implants in implant-supported FDPs (n = 1,753).



Discussion

Teeth may be lost as a consequence of disease or trauma, or may simply be congenitally missing. Their replacement, where indicated, can be a tooth-supported, implant-supported/retained, or tissue-supported prosthesis. While the provision of a particular prosthesis is often a subjective choice (guided by the dental professional), the increasing awareness of implant related dentistry, both within the profession and by the public at large, has seen a rapid increase in the application of this treatment modality.

In the first 8 years of the author's practice, the fixed prosthodontics component was almost exclusively related to tooth-supported prostheses (97%). Subsequent to 1991, there has been an increased use of osseointegrated implants to support the replacement of missing teeth. By 2007, 81% of all fixed tooth replacement prostheses provided in the practice were IFDPs.

This has resulted in a change in the type of prosthesis provided in this particular practice. The practice accepts referrals for all classes of fixed and removable prostheses and has not sought increased referrals specifically for implant-related dentistry. Teeth require crowns to improve esthetics or structural integrity. There has been no marked decrease in the provision of TSCs following the initial years of the practice's establishment. Simply put, implants replace missing teeth. The results have clearly shown that the increase in the provision of IFDPs has coincided with a decrease in TFDPs. This is most likely due to the availability and community awareness of the implant therapy option.



Fig 5a Teeth replaced using tooth-supported FDPs (TFDPs) (n = 1,234).







Fig 6 Number of three-unit toothsupported FDPs (TFDPs) and implant-supported single crowns (ISCs) from 1988 to 2007.





 Table 1
 Summary of Profile and Incidence of Tooth- and Implant-Supported Prostheses

Incidence of provision of prostheses

Marked increase in the provision of implants restored after 1991 ($n = 913$)
TSCs (n = 2,678) provided in 60% of TEs
TFDPs (n = 749) provided in 34% of TEs
IFDPs (n = 386) (182 ISCs, 150 PIFDPs, 54 FIFDPs) provided in 19% of TEs
Decreasing number of TFDPs over time (range: 55 in 1989, 8 in 2007)
IFDPs accounted for 81% of tooth replacement prostheses in 2007
Gender and Age
Of 749 TFDPs, 61% were in females and 39% in males
Of 386 IFDPs, 55% were in females and 45% in males
Of 2,678 TSCs, 69% were in females
Of 1,135 tooth-replacement prostheses (749 TFDPs, 386 IFDPs), 56% were in females
IFDPs (35%) in the under-31 age group were more common than TFDPs (19%)
IFDPs in the under-21 age group were more common in females (9%) than in males (4%)
IFDPs in the 21 to 30 age group were more common in males (21%) than in females (13%)
Abutments (excluding third molars)
Tooth
Maxillary canines (19%) and central incisors (14%) were most common
Mandibular incisors (2.5%) and first molars (1%) were least common
Implant
ISCs were concentrated in the anterior maxilla (71%)
FIFDPs and PIFDPs were evenly spread throughout each arch
FIFDPs accounted for the high number of implants in the mandibular incisor region (11%)
Teeth replaced (excluding third molars)
Tooth
Maxillary canines (4%) and second molars (2%) were least frequently replaced teeth
Mandibular first molars (12%) were most frequently replaced teeth
Implant
ISCs concentrated in the anterior maxilla (71%)
IFDPs were evenly spread throughout each arch
Changes in tooth-supported FDP characteristics
Decrease in maxillary three-unit TFDPs
Decrease in TFDPs with four or more pontics
Decrease in TFDPs that do not obey Ante's Law
Decrease in use of tooth abutments with an unfavorable 10-year prognosis

In general, females are more concerned with the esthetic appearance of their teeth than males.⁶ TSCs that were provided were almost exclusively porcelain or metal-ceramic and mostly for esthetic considerations; of the TSCs provided, 69% were in females. Tooth replacement prostheses are provided for not only esthetic demands, but also comfort and function–factors likely to be as relevant to males as females. This accounts for the more even gender distribution (56% in females, 44% in males) of the tooth replacement prostheses (tooth- or implant-supported).

IFDPs avoid using teeth as abutments. This has significantly reduced the need to use either unblemished or structurally compromised teeth in TFDPs. Young adults (< 31 years) referred to the practice required replacement of teeth predominantly because the teeth were either congenitally missing or had been lost through trauma, especially those in the anterior maxilla. These edentulous, mostly one-tooth spaces had a high incidence of unblemished adjacent teeth as a result of the patient's exposure to fluoridated water supplies and decay preventing hygiene measures.^{7,8} The use of these unblemished teeth as FDP abutments would command a high biologic price. This accounts for the higher number of IFDPs, especially ISCs in the anterior maxilla, than TFDPs in this age group for both genders.

Male patients had a higher incidence of tooth loss due to trauma in the 21 to 30 age group than their female counterparts. This reflected the incidence of trauma in the general population, which forms the referral source for the practice⁹ and accounts for the increase in use of IFDPs in this age group for males (21%) compared to females (13%).

The alternative treatment for a single-tooth edentulous space is a three-unit TFDP. Conventional threeunit TFDPs have positive long-term outcomes, especially when associated with vital and structurally sound abutments,¹⁰ but involve much destruction of the abutment tooth's structure. The comparative long-term outcome of bonded TFDPs is much reduced.^{11,12} The results of this observational report clearly show that the number of three-unit TFDPs has decreased as the use of ISCs has increased.

As the population exposed to the benefits of water fluoridation ages, the number of potential unblemished abutments surrounding edentulous spaces will increase, indicating a justified increase in the use of biologically conservative implant-supported prostheses.

There is much debate regarding the appropriate age for implant placement in the young adult.¹³ It is accepted, however, that female growth attenuates adequately enough for implant placement at a younger age (around 15 years) than in males (around 18 years).¹⁴ This difference in gender age maturation is reflected by the relatively high numbers of female patients in the under-21 age group receiving implant prostheses (9%, the youngest being 15) when compared to males (4%, the youngest being 18). IFDPs are a conservative treatment option, especially for the replacement of the comparatively greater number of congenitally missing teeth in females.¹⁵

The second group of potential abutments for TFPDs has suffered the ravages of caries, periodontal disease, and attrition/erosion, and may be nonvital and structurally or biologically compromised. The use of these teeth to support crowns or retainers for FPDs can place them at risk of structural failure, especially in long-span situations. Fracture of abutment teeth has been identified as a significant cause of failure of TFDPs, with a higher incidence of failure in root-filled abutments¹⁶⁻¹⁹ and those with an unfavorable 10-year prognosis.¹⁹ Prior to implant dentistry, many compromised teeth were maintained to avoid creating a new or larger edentulous space. The paradigm has changed and these teeth are often now extracted and replaced with implants. The reported results clearly show a marked decrease in the use of abutment teeth with an unfavorable 10-year prognosis, particularly those considered to have compromised periodontal support.

TFDPs vary in their complexity and length. In this analysis, both Ante's Law and the number of pontics were included to indicate these factors. Although Ante's Law has been shown to have little relevance to the longterm outcome of TFDPs,²⁰ it still provides an indication of edentulous span length relative to abutment support. For example, a TFDP with four or more pontics may have as few as two abutments (and not satisfy Ante's Law) or as many as 12 (and satisfy Ante's Law). TFDPs that do not satisfy Ante's Law are perceived to place more strain on the abutment teeth, while TFDPs with multiple abutments may incorporate more complex prostheses designs. For different reasons, both of these TFDP constructions may compromise the long-term outcome of the prosthesis. Reducing the complexity and length of TFDPs by use of IFDPs would seem ideal. It is evident that with the incorporation of implant dentistry, there has been a marked reduction in the use of longspan and complex TFDPs

The trend for an increasing number of implantsupported prostheses provided in the over-65 age group for both genders reflects the increased use of FIFDPs, which have excellent long-term outcomes,²¹ instead of tissue-supported complete dentures. This is especially evident in the mandible, where tissuesupported complete dentures are often poorly tolerated. The marked increase in the use of anterior mandibular implant abutments and mandibular anterior teeth replaced in comparison with their tooth-supported counterparts, is attributable to the provision of these mandibular FIFDPs. However, given the fiscal cost involved, tissue-supported dentures (with or without added implant retention) will likely always be a part of prosthodontic practice.

The incorporation of osseointegrated implant dentistry has clearly changed the patient profile and type of fixed prostheses provided in this practice. It is hypothesized that the decrease in the use of compromised teeth for either TSCs or TFDPs, as well as the reduction in complexity and length of TFDPs, has resulted in an improvement in the long-term outcome of these prostheses. The author will explore this in a subsequent paper.

Conclusions

The incorporation of osseointegrated implant dentistry into a specialist prosthodontic practice has resulted in the following:

- 1. Decrease in the number of TFDPs provided annually.
- 2. Greater number of patients less than 31 years old referred to the practice.
- 3. Greater number of teeth replaced in the anterior mandible with fixed prostheses.
- 4. Decrease in three-unit TFDPs corresponding to an increase in ISCs.
- 5. Decrease in the use of long-span and complex TFDPs.
- Reduction in the use of tooth abutments that are structurally or biologically compromised.

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