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Immediate loading of dental implants

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ABSTRACT

The purpose of this review is to explore the concept of immediate loading as it pertains to dental implants and the indications for clinical practice. The definition of immediate loading will be considered together with a review of the relevant literature in an attempt to provide evidence-based guidelines for successful implementation into practice.

A search of electronic databases including Medline, PubMed and the Cochrane Database of Systematic Reviews was undertaken using the terms ''immediate loading'', ''dental implants'', ''immediate function'', ''early loading'', ''oral implants'', ''immediate restoration'' and ''systematic review''. This was supplemented by handsearching in peer-reviewed journals and cross-referenced with the articles accessed. Emphasis was given to systematic reviews and controlled clinical trials.

A definition of immediate loading was suggested pertinent to the realities of logistics in clinical practice with respect to application and time frame. The literature was evaluated and shown to be limited with significant shortcomings. Guidelines and recommendations for clinical protocols were suggested and illustrated by examples of case types with a minimum of 1–3 years follow-up. A list of additional references for further reading was provided.

Within the limitations of this review, there is evidence to suggest that immediate loading protocols have demonstrated high implant survival rates and may be cautiously recommended for certain clinical situations. However, more high level evidence studies, preferably randomized controlled trials (RCTs), over a long time frame are required to show a clear benefit over more conventional loading protocols.

Key words: Dental implant, oral implant, osseointegration, level of evidence, immediate loading, early loading, immediate implants, guided surgery.

Abbreviations and acronyms: CT = computerized tomography; EBP = evidence-based practice; RCT = randomized controlled trial; RR = relative risk; 3-D = three dimensional; SDT = same day tooth or teeth; SVT = same visit tooth or teeth.

INTRODUCTION

Since time immemorial it has seemed obvious to lay people that a lost tooth might be replaced by insertion of a replacement object into the lost tooth site. Many examples of such attempts have been found archaeologically. Subsequently, early dental writings described approaches to implanted dental replacements, however the natural history of failure clearly established that the concept involved considerable difficulty and uncertainty. The advent of antibiotics escalated the use of dental implants, however failure rates and complications were so high that by 1960 the dental establishment had come to consider the practice as dubious and consequently in many parts of the world implants were viewed with scepticism and discontinued.

In the late 1960s, Brånemark *et al.* in Sweden introduced the concept of osseointegration whereby predictable long-term implant function could be achieved following a strict protocol.[1] This documented the installation of titanium implants involving a submerged healing phase of between 3 to 6 months depending on bone quality, followed by a delayed phase of prosthetic loading on cross-arch fixed prostheses in the edentulous jaws. Twenty-five years later patient mediated requests for an expedited treatment process led clinicians and researchers to look at means of reducing the healing phases, reducing surgical procedures and providing a functioning prosthesis in the shortest time frame, with success rates at least similar to conventional loading protocols. By 2000 a large volume of literature pertinent to immediate loading was available. The principal factors associated with the expanding clinical application were protocols aimed at improving and maintaining the primary stability of implants, the introduction of osseoconductive implant surfaces enhancing the secondary stability of implants by promoting improved levels of osseointegration, and a better understanding of controlled functional loading.

Table 1. Key points of review

Evidence-based practice and the PICO question
Definition of immediate loading
Patient mediated factors
Biological basis for immediate loading
Marginal tissues response
Guidelines for immediate loading
Guided surgery

This review is aimed at providing evidence-based guidelines for the successful implementation of immediate loading of dental implants into clinical practice.

Key points of review

The key points of review are: evidence-based practice and the PICO question; definition of immediate loading; patient mediated factors; biological basis for immediate loading; marginal tissues response; guidelines for immediate loading and guided surgery (Table 1).

Evidence-based practice and the PICO question

The application of evidence-based medicine concepts into the dental arena has been met with varying levels of enthusiasm from clinicians and researchers. Misconceptions have arisen regarding what constitutes evidence-based practice (EBP) with some protagonists taking an overly radical view of what constitutes evidence. Sackett[2] wrote that evidence-based practice is ''the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients … It involves the integration of individual clinical expertise, with the best available external clinical evidence''.

The construct of evidence-based practice is that not all evidence is equal. Higher quality evidence is less likely to suffer from systematic errors, bias and has more statistical validity. Therefore, to analyse the evidence available on a particular subject it must be placed in a hierarchical order as shown in Table 2.[3]

Table 2. Level of evidence for effectiveness of interventions in clinical studies.*

1a	Systematic review of RCTs
1b	Individual RCT (with narrow confidence intervals)
2a	Systematic review of cohort studies
2b	Individual cohort study (including low-quality RCT, e.g. <80% follow-up
2c	Outcomes research, ecological studies
3a	Systematic review of case-control studies
3b	Individual case-control study
4	Case-series (and poor-quality cohort and case-control studies)
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or ''proof of principle study''

*Adapted from Centre for Evidence-Based Medicine; http://www.cebm.net/index.aspx?o=1025.

When discussing therapy, the ideal investigation is the randomized controlled trial (RCT) which in dentistry can be difficult to implement and expensive to run. Before this ideal, research often must start on a base of laboratory research, pilot clinical trials and case series before progressing to controlled trials. The pinnacle of evidence is the systematic review of all pertinent RCTs, of which the Cochrane review is the gold standard.

A Cochrane review is a meta-analysis to improve statistical validity. These studies, primarily RCTs, are strictly selected on the basis of quality of design and freedom from bias and other errors. Thus the Cochrane review is as independent and objective as possible.[4]

Making clinical decisions using the Cochrane Collaboration should be a simple matter and greatly reduce the reading load whilst ensuring that the practitioner was current and evidence-based. However, as with most aspects of life, reality is not so simple. Cochrane reviews need to be, by definition, focused to a narrow question so that the question the clinician is posing may not be answered by a review, i.e., is not applicable to the clinician's practice. There is a paucity of quality RCTs as attested to in most Cochrane reviews and lamented by other systematic review authors. As with the systematic reviews quoted in this paper, valuable articles with treatment provided for a considerable number of patients, often prospective and multicentre, are excluded because of the strict requirement for a randomized controlled trial. Randomized controlled studies on immediate loading of implants are often not truly randomized as the clinician decides whether to load the implant at the time of surgery. Loading of an implant in the absence of sufficient initial stability would be unconscionable for most ethical clinicians. Valid criticism may be leveled at systematic reviews and meta-analyses that are attempted but fail due to heterogeneity and the poor quality of RCTs available. These reviews consequently fall back to qualitative reviews covering a very small percentage of the available literature. As a result most reviews reach equivocal recommendations for the practising clinician.

An alternative review is a narrative review conducted by recognized experts in the field. This type of review usually has a broader base of general literature, including case series, with which the reviewers may come to some conclusions. However, the criticism is often that the selection of articles is more to support the argument of the author and hence subject to bias. Further to the narrative review is the consensus conference. Armitage in 2005 stated that ''a traditional consensus conference is an appropriate way to arrive at the best current way to do something if the knowledge base is insufficient to make a scientifically rigorous

evidence-based analysis of the clinical problem. The result is the best opinion of experts in the field''.[5] Currently, four consensus papers have been written on this subject.[6–9] This review will attempt to find a middle ground by principally looking at the highest level of evidence – the systematic review and then relating this evidence with a selected number of supporting studies. The key ingredient for this systematic process is the development of an answerable question using the **PICO** formula, where **P** corresponds to a population or problem, **I** the intervention being investigated, **C** a comparison treatment and **O** the outcome desired.[3] A PICO question pertaining to this review could thus be constructed as:

Population	For patients requiring dental implants
Intervention	Does immediate loading
Comparison	Compared to conventional loading protocols
Outcome	Give comparable or superior results and satisfaction for the patient?

A search of electronic databases including Medline, PubMed and the Cochrane Database of Systematic Reviews was undertaken using the terms ''immediate loading'', ''dental implants'', ''immediate function'', ''early loading'', ''oral implants'', ''immediate restoration'', and ''systematic review''. This was supplemented by handsearching in peer-reviewed journals and cross-referenced with the articles accessed. Emphasis was given to systematic reviews and controlled clinical trials. Inclusion criteria dictated studies from 2000 reflecting best evidence and historical papers included for illustrative purposes. Titles and abstracts obtained from the electronic search were independently screened by both authors. The full text was reviewed of all papers considered suitable for inclusion by either of the reviewers. Papers were then assessed independently by both reviewers against the inclusion criteria and discussed. Twenty-four consensus reports and review papers have been published on immediate loading of dental implants. This large number suggests that immediate loading is a field that is still developing and currently leaves room for different interpretations and philosophies.[10]

Definition of immediate loading

Consensus reports and systematic reviewers alike have attempted to define the term immediate loading from both the context of timing of the prosthesis and the amount of occlusal loading it receives. Immediate loading is often defined in terms of timing as at the same clinical visit as implant placement. With the single implant scenario this is often achievable and may be advantageous in supporting soft tissue contour.[10] When considering partial and complete edentulism, the logistics of providing a provisional restoration often dictate a delay from the time of implant placement. For this reason as opposed to any biological basis, ''immediate'' is most often defined as ''within 48 hours''.[7,9,11,13]

The amount of occlusal loading the provisional restoration supports is also the subject of debate with respect to definition. The terms ''immediate loading'' is reserved for full occlusal loading in at least centric occlusion and ''immediate restorations'' or ''non-occlusal loading'' for restorations with no centric or eccentric contacts.[6,9,10,12] The restoration will of course still have a degree of function with respect to aesthetics, speech and food bolus contact. A summary of various definitions of immediate loading is shown in Table 3.

Patient mediated factors

Previously there have been a number of medical conditions that contraindicate implant treatment with conventional protocols. More recently, it has been established that there are no absolute contraindications to implant placement although a number of conditions exist that are associated with an increased risk of failure. Moy *et al.* in a recent retrospective cohort study of 4680 implants over 21 years, patients in the 60–79 age group showed a relative risk (RR) of 2.24, diabetics (RR = 2.75), head and neck radiation (RR = 2.73) and post-menopausal oestrogen therapy (RR = 2.55).[14] These risk factors have not been analysed in the immediate loading context. Prudence however, has probably resulted in many authors considering the above factors as contraindications in immediate loading

Table 3. Definitions of immediate loading

Review	Definition of immediate loading	occlusal vs non-occlusal loading	No. of studies	Follow-up	Level of evidence
Aparicio 2003	within 72 hrs	full occ contact	consensus	N/A	5
Cochran 2004	within 48 hrs	full occl contact	N/A	N/A	5
Attard 2005	not defined	not defined	not specified	N/A	5
Glauser 2006	within 24 hrs	not defined	17	>12 months	5
Nkenke 2006	within 72 hrs	full occl contact	5	>12 months	1a
Wang 2006	within 48 hrs	clin judgement	consensus	N/A	5
Esposito 2007	within 1 week	same	8	6–12 months	1a
Jokstad 2007	not defined	not defined	22	>12 months	1a
Cooper 2007	same visit	clin judgement	N/A	N/A	5

studies. Bisphosphonate medication has emerged in recent times as a risk factor for the development of osteonecrosis of the jaw. Limited data exist as to the incidence of this debilitating condition in relation to implant treatment and oral or intravenous bisphosphonate therapy at this point in time.[15] Therefore, most clinicians consider these drugs to be a contraindication to immediate loading of dental implants.

A recent retrospective study on 1925 implants to 16 years reported a significantly higher failure rate where patients were unable to utilize postsurgical amoxicillin (RR = 3.34).[16] In the same study, implants placed into sites where teeth were removed for periodontal reasons were 2.3 times more likely to experience implant failure.

Smoking has been associated with a significantly higher failure rate.[14,17] De Luca *et al.* found a RR rate of 1.69 over a 20-year period analysing 1852 implants, concurring with the study of Moy *et al.* Another study however, in a randomized comparison between machined and oxidized surface implants supporting immediately loaded prostheses in the posterior mandible, found an increased failure rate was experienced in smokers receiving the machined surface,[18] but the oxidized surface showed no statistical increased failure rate even though more smokers and more implants were placed in the oxidized surface group. The role of smoking in the success rate of immediately loaded implants at this point of time must be considered inconclusive with modified surfaced implants appearing to play a significant role.

No data exist to support the superiority of good bone quality.[10,19] The region of the mouth most studied, the anterior mandible, with the highest level of evidence for immediate loading, also has the most consistently high quality of bone where Type 1 and 2 bone is most often encountered. Therefore, a greater potential exists for high initial stability of the implant. Most studies support conventional drilling protocols for placement of implants in the anterior mandible. Generally, authors agree that the quality of bone is significant for success in immediate loading. However, there have been no studies that have specifically tested this hypothesis.

Poor bone quality (Type 4) often found in the posterior maxilla is associated with higher failure rates.[18,20] When softer bone is encountered, a revised drilling protocol is employed, designed to enhance primary stability by underpreparing the site. This may involve reducing or avoiding tapping; avoiding countersinking to maximize cortical bone contact; engaging both cortices for bicortical stabilization; underpreparation by using narrower drills than the usual protocol; the use of osteotomes; self-tapping threaded implants and different geometries of implant design for increased compression of the site.[6,8–10,13,18,19] The number of different protocols and techniques has led to a level of heterogeneity that is difficult to compare and on which to reach definitive conclusions. The prudent experienced clinician is entrusted to treat each patient individually depending on the bone quality encountered, being cognizant of the need to attain a high initial stability of the implant. A high level of clinician experience and competency has been emphasized as necessary for immediate loading protocols.[19,21,22]

No data exist to support the superiority of implant length or implant diameter,[10,19] however most authors have stipulated a minimum length of 10 mm for immediately loaded implants. Increased length is important especially in extraction sites to engage apical bone, engagement of cortices for bicortical stabilization and an increased area of bone compression where underpreparation of the site is employed. Concurrent use of a larger diameter implant for increased surface area has been suggested for the same reasons. These concepts have less importance in sites with a large cortical component.

Screw type implants have shown a significant superiority compared to press-fit implants because their design allows a greater initial bone contact, i.e., within the threads and a mechanical locking to achieve initial stability. Therefore, the threaded implant does not require osseointegration to resist load. This is obviously more important in the immediate loading context.[7,8,19,21,22]

Biological basis of immediate loading

Cooper defined three biologic factors to consider for osseointegration to occur with immediate loading: (1) factors affecting osteogenesis (bone formation); (2) factors affecting peri-implant osteolysis (bone resorption); and (3) micromotion effects on peri-implant osteogenesis.[13] Osteogenesis is time dependent so the maintenance of implant stability is critical. The initial stability of the implant reduces in the first 3–6 weeks after placement due to remodelling and an increased ratio of woven to lamellar bone. The implant bone interface thus becomes more susceptible to the effects of micromotion. The threshold at which osteogenesis will be detrimentally affected is generally considered to be 150 μm.[10,13] Clinically, this can be minimized with rigid splinting of implants where applicable and the reduction of occlusal load.

Oxidized surface implants have shown to be beneficial in reducing loss of stability[28] in comparison with machined surface implants.[18] Modified surfaces are recommended in most reviews.[7,10,19] This effect is postulated to be due to an increased surface area and hence greater bone to implant contact and stabilization of the blood clot and fibrin network, thereby initiating contact osteogenesis in comparison to distance osteogenesis, i.e., apposition to the old bone of the

osteotomy toward the implant. This is particularly important in soft bone that has a reduced capability to resist mechanical load.[8,18]

Marginal tissue response

Stable peri-implant tissues involving marginal bone levels and soft tissue contours over time are decisive for long-term success. A systematic review of marginal soft tissue at implants subjected to immediate loading or immediate restoration reported that within the limits of the evaluated data, it can be cautiously concluded that once immediately loaded or restored implants integrate successfully, they appear to show a soft-tissue reaction with regard to peri-implant area as well as morphologic aspects comparable with those of conventionally loaded implants.[11] However, follow-up periods are generally short, number of implants per study are few, and most studies present only limited data on peri-implant soft-tissue evaluation. More accurate long-term studies with a stronger study design (i.e., RCT) reporting more detailed treatment and follow-up protocols are required to allow proper comparisons and conclusions.[11] Because of the lack of long-term data, questions regarding whether peri-implant health, prosthesis stability, degree of bone loss, and aesthetic outcome of immediate implants are comparable with implants placed in healed sites remain unanswered.[23]

Guidelines for immediate loading

Within the limitations of this review, some guidelines for the practising clinician can be given. The most salient feature of all the reviews is that immediate loading of implants is a modality requiring a higher degree of experience and clinical competency. The success rates presented are usually similar to but not necessarily better than a conventional loading protocol. For this reason, the inexperienced or developing clinician should default to the conventional loading protocol if the clinical situation is not optimal. Patient-mediated factors discussed such as systemic disease or medication compromising bone healing, diabetes, parafunction and smoking should be taken as a contraindication to immediate loading. The implant placement should be performed to achieve a high level of stability. Most agree that an insertion torque of at least 32 Ncm is required[6,9,11,19] and a resonance frequency analysis of at least 60 ISQ where this test was employed.[24] The overall evidence base is weak and relatively empirical and consequently signifies the need for more high quality controlled clinical studies to investigate these variables.

The edentulous mandible possesses the highest level of clinical evidence suggesting that a fixed prosthesis on at least four implants placed interforaminally will give a high degree of success. Sufficient evidence also exists to support placement of two implants, splinted or unsplinted, to retain an overdenture when the opposing dentition is a complete denture. Pilot research also exists to suggest 1 implant in the midline symphysis may be a viable treatment modality.[24] The edentulous maxilla has more limited evidence to support at least 4 implants and a fixed prosthesis, however most studies have at least 6 implants. Evidence for the use of immediately loaded overdentures in the maxilla is not available. Partially edentulous fixed prostheses in either jaw have limited evidence to support an immediate loading protocol due to the heterogeneity of the studies. Good results have been achieved in many studies, however the small number of patients treated and implants placed together with generally short follow-up times preclude definitive conclusions. The single tooth implant, particularly in the maxilla has many studies showing a high level of success. Most however, have short follow-up periods and strict exclusion criteria. The role of occlusion, in particular, has yet to be determined. The presence of parafunction or an unfavourable occlusal scheme is a definite contraindication in most studies, and in the eyes of most experienced clinicians when dealing with short span replacements. A summary of immediate loading evidence and guidelines for use in different applications is shown in Table 4.

Table 4. Summary of immediate loading evidence and guidelines

Clinical scenario	Evidence base	Guideline for use
Edentulous maxilla		
Overdenture	Experimental	Not recommended
Fixed prosthesis	Weak	Caution
Edentulous mandible		
Overdenture	Good	Routine
Fixed prosthesis	Good	Routine
Partial edentulism		
Posterior maxilla	Weak	Caution
Anterior maxilla	Weak	Caution
Posterior mandible	Weak	Caution
Anterior mandible	Weak	Caution
Single tooth implant		
Molar maxilla	None	Not recommended
Premolar maxilla	Good	Selected cases
Anterior maxilla	Good	Selected cases
Molar mandible	Experimental	Not recommended
Premolar mandible	Weak	Selected cases
Anterior mandible	Weak	Selected cases

Guided surgery

Guided surgery is applicable to all implant indications by using conventional modeling or computer-aided three-dimensional (3-D) design. It offers more precise planning, greater predictability and safety, and flapless procedure with minimal morbidity together with decreased postoperative discomfort. Furthermore, the

possibility of pre-production of the prosthesis can enhance practice productivity and benefit both patients and dentists. However, the evidence to support this concept over traditional forms of treatment is limited. In one prospective multicentre study the patients received their final prosthetic restoration immediately after implant placement, i.e., both the surgery and the prosthesis insertion were completed within approximately one hour.[25] It was concluded that the prefabrication, on the basis of models derived from 3-D oral implant planning software, of both surgical templates for flapless surgery and dental prostheses for immediate loading, is a very reliable treatment option. It is evident that the same approach could be used for staged surgery and in partial edentulism.

Relevance for clinical practice

Immediate loading has an emerging and increasing application for all clinical indications with the exception of the immediately loaded maxillary overdenture. Whilst the application is limited with respect to EBP, the results of over 100 papers on the subject have encouraged practitioners to employ clinically documented protocols in selected cases.

The immediate loading of implants can be carried out using single stage surgery and flap approach dependent on whether an extraction is involved or not, or using single stage surgery with a punch or flapless approach. These protocols may be completed at the same visit, same visit tooth or teeth (SVT), or during the same day if laboratory phases of provisional prosthesis fabrication involve same day tooth or teeth (SDT). These protocols are illustrated in Table 5 for the single tooth application and in Table 6 for multiple tooth applications. Various presentations of the partially edentulous jaw can be managed by any of the protocols dependent on complexity and numbers of missing teeth.

Patient 1: edentulous mandible

Figure 1 illustrates a 15-year long-term follow-up of immediate loading in the mandible carried out in a pilot study in the early days of immediate loading development.[26] A group of patients received 6 implants, 2 of which were left "sleeping" in the event of implant failure necessitating subsequent prosthetic connection. The study reported no implant failures. Clinical protocol involved a flap and fixed prosthesis connection as soon as it was possible dependent on laboratory fabrication. The pre-existing denture was relieved and reinserted with tissue conditioner as interim treatment.

Table 5. Single tooth concepts for immediate restorations

SAME VISIT TOOTH (SVT)	SAME DAY TOOTH (SDT)
Evaluation	Evaluation
± Extraction	± Extraction
Implant	Implant
Direct Temporary Crown	Surgical Impression
3–6 months Prosthetic Impression	Laboratory Final Abutment & Scan Temporary Crown
± Permanent Abutment	3-6 month Permanent Crown
Permanent Crown	

Table 6. Multiple tooth concepts for immediate loading

SAME VISIT TEETH (SVT)	SAME DAY TEETH (SDT)
Evaluation	Evaluation
Prepare Radiographic Guide	± Extraction Implants
CT Scan	Surgical Impression
Software Treatment Planning	± Laboratory Abutment Selection
Manufacture Stone Model & Surgical Index	Provisional Prosthesis
Manufacture Prosthesis	3–6 months Permanent Prosthesis
Implants + Prosthesis Insertion	

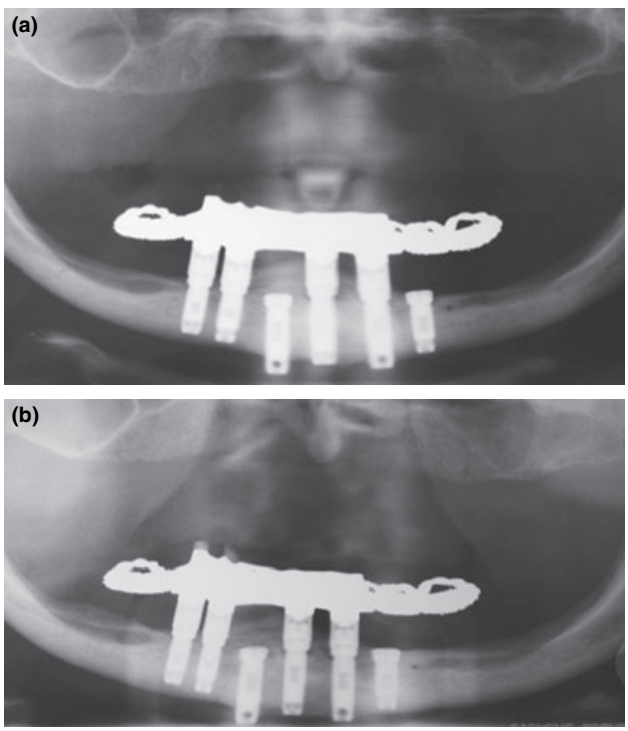

Fig 1. Patient 1. (a) Postoperative panoramic radiograph on 62-year-old female patient, immediately loaded prosthesis on 4 implants. (b) Postoperative panoramic radiograph at 15-year follow-up. Notice little discernable difference of marginal bone height and some evidence of remodeling of the body of the mandible.

Patient 2: edentulous mouth

Following success of this study our routine clinical procedure from 1993 onwards became 4 implants

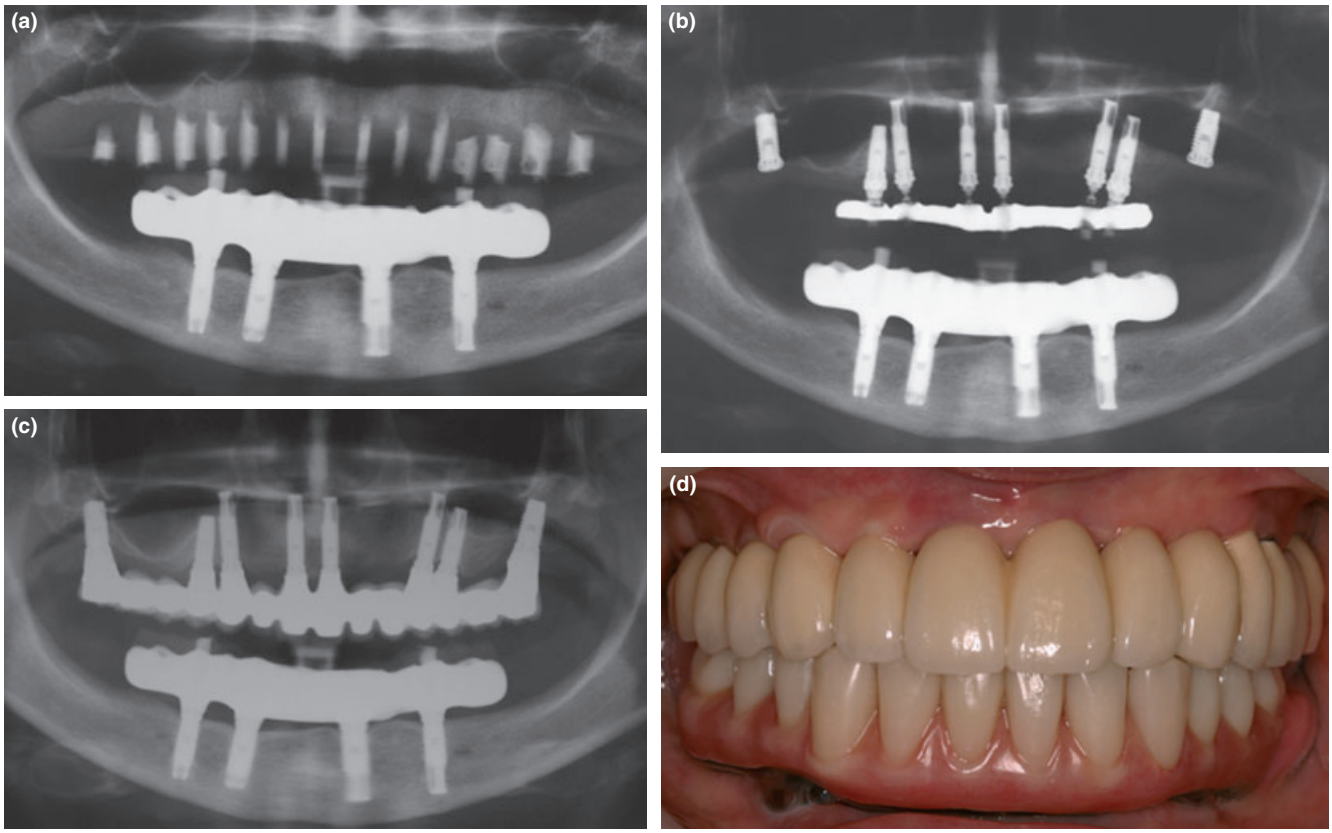

Fig 2. Patient 2. (a) Panoramic radiograph illustrating 5-year follow-up SDT immediate loading in the mandible. Maxillary view shows radiographic template for bone evaluation. (b) Postoperative panoramic radiograph maxilla showing provisional prosthesis and SDT protocol. Distal implants were planned for 2-stage surgery because of soft bone quality and osteotome sinus lift procedure. (c) 2-year panoramic radiograph follow-up maxilla and 7-year follow-up mandible. (d) Intra-oral view of aesthetic outcome.

immediately placed for rehabilitation of the edentulous mandible using SDT protocol as described in Table 6. Figure 2 illustrates this procedure and the maxilla was subsequently treated in a similar fashion several years later.

Patient 3: guided surgery

Five years ago we were involved in a prospective multicentre study which provided an SDT solution for the edentulous mandible using a preformed drill guide and prosthetic bar system for prosthesis fabrication.[27] This study demonstrated that SDT on 3 machined implants with prefabricated bridgework in the mandible can result in high implant success, patient satisfaction and significant reduction in treatment time. The mean marginal bone loss after one year in this study was 0.4 mm which compared favourably with the Brånemark research.[1] An example of a patient from this study is shown in Fig 5 and following the positive response to the mandibular treatment this patient was the first in Australia to undergo guided surgery for immediate edentulous maxillary rehabilitation.

Patient 4: partially edentulous anterior maxilla

Patient 4 presented with failing porcelain fused to metal crowns, ill-fitting post/cores and endodontic problems with 11 and 21 as shown in Fig 4. After full discussion and consent, the 11 and 21 were removed, sockets curetted and verification of the presence of a labial plate. Two tapered, oxidized surface implants, using a flapless approach, were placed immediately utilizing the palatal wall of the socket. The labial plate was not touched by drills or implant. Autogenous bone was used for socket infill between implant and the labial wall of the socket. The implants had a high degree of stability and an insert torque of 45 Ncm. Two splinted, acrylic resin, screw-retained provisional crowns on temporary titanium abutments were placed later the same day. The occlusion was adjusted to provide disclusion by the lateral incisors. The provisional crowns were placed out of any centric or eccentric contacts. The patient was placed on a soft diet and instructed not to bite directly on the provisionals. The final restorations consisted of separate all-ceramic crowns cemented to titanium abutments finalized six months later.

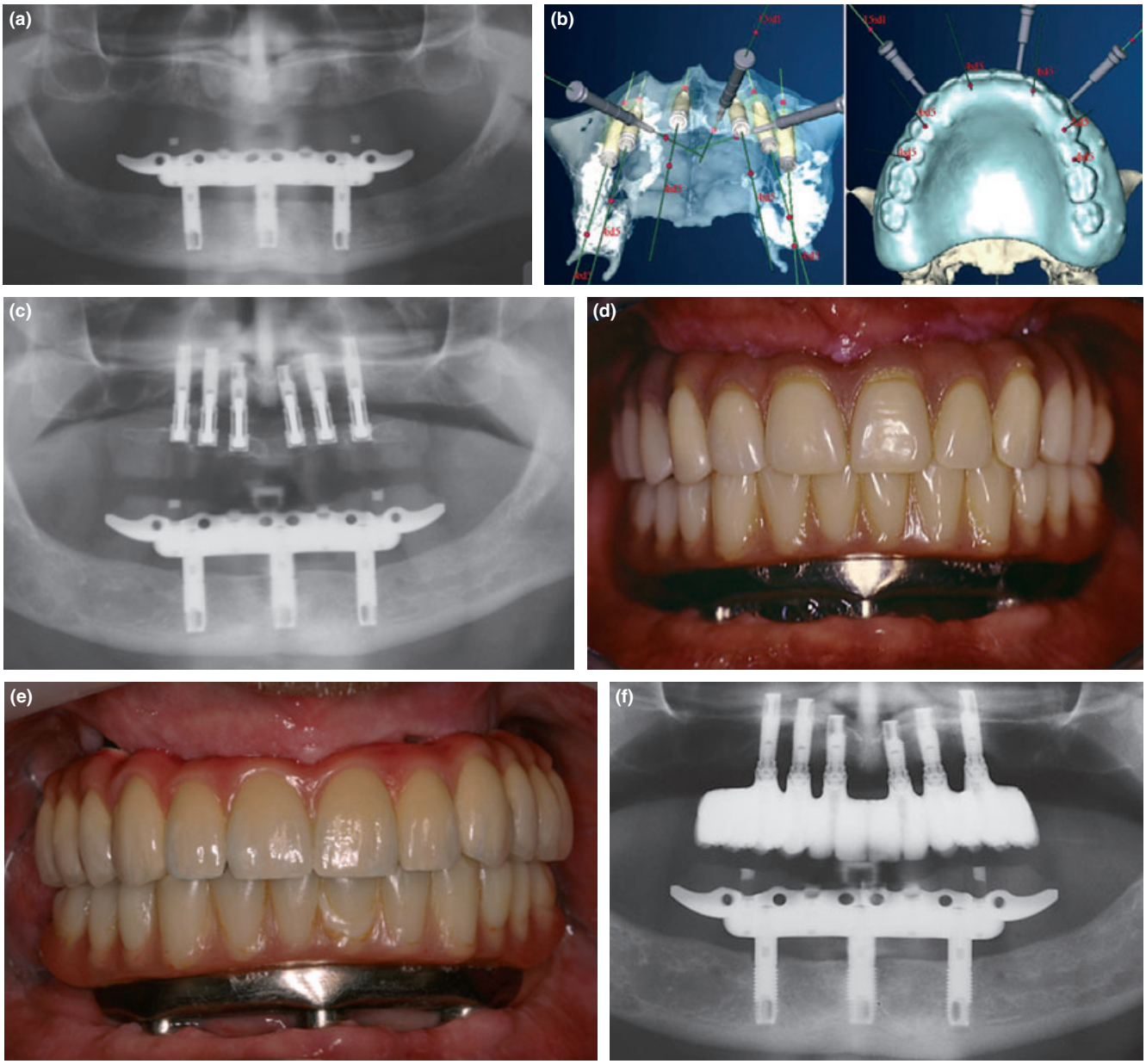

Fig 3. Patient 3. (a) Panoramic radiograph, postoperative view mandibular SDT using prefabricated componentry. (b) Guided surgery software planning maxilla. (c) Postoperative panoramic radiograph SVT maxilla with provisional prosthesis. (d) Postoperative clinical view, maxilla SVT provisional prosthesis. (e) Clinical view finalized prostheses, porcelain fused to metal fixed prostheses maxilla, hybrid titanium acrylic prosthesis, mandible. (f) Postoperative radiographic follow-up 4 years maxilla, 6 years mandible.

Patient 5: single tooth healed site premolar maxilla

Patient 5 presented requesting implant replacement of missing 24. Ridge width, bone volume and occlusal relationship were favourable for immediate provisionalization. After full discussion and consent, a flap was raised and a tapered oxidized implant was placed with a high degree of stability and an insert torque of 45 Ncm. A titanium temporary abutment was utilized to construct a screw-retained acrylic resin crown. The peri-implant tissues had remodelled at three months and the final restoration consisted of a screw-retained porcelain fused to gold abutment crown. The treatment is illustrated in Fig 5.

Patient 6: SVT, anterior maxilla

The use of 3-D computer software in the partially edentulous jaw is shown in Fig 6. The 31-year-old female presented with traumatic loss of a 4-unit bridge supported on the maxillary lateral incisors. The labial plates of both teeth were lost and a large nasopalatine canal was present. The patient rejected bone grafting and requested SVT which she had learned about on the internet.

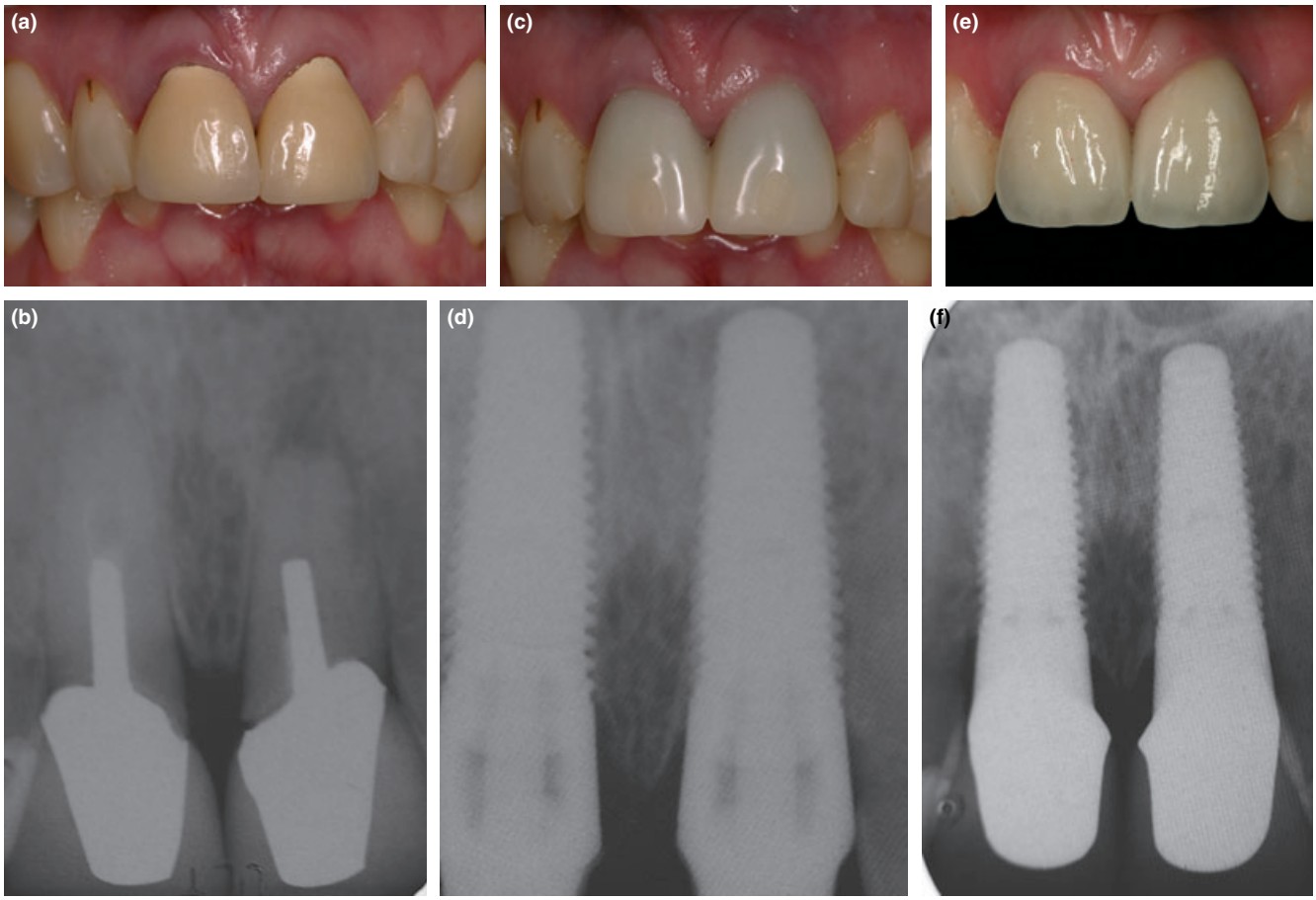

Fig 4. Patient 4. (a) Prosthetic and endodontic failure of 11 and 21. (b) Periapical radiograph of presenting condition. (c) The teeth are removed and two tapered oxidized surface scalloped implants are placed immediately, anchored in the palatal aspect of the sockets. Autogenous bone is used for socket infill and provisional screw retained crowns are placed on the day of implant placement. (d) Periapical radiograph on the day of implant placement. (e) Clinical view 4 years, all ceramic crowns cemented on titanium abutments. (f) Periapical radiographic view 4 years.

Although residual bony architecture was minimal, careful planning revealed sufficient bone for the installation of implants in the central incisor regions.

DISCUSSION

The literature search in this review imposed a limit of 20 references reflecting best evidence with up to 10 additional references as resource material. Therefore, the review rested heavily on systematic reviews and outcomes of consensus conferences rather than individual articles. The overwhelming consensus amongst systematic reviews is that the quality of RCTs is lamentably poor. Not included are much better case series from recognized centres of excellence that would provide evidence for a procedure but do not compare against a "control". The transfer of evidence-based practice concepts from medicine to dentistry has some important differences especially with implant treatment. An RCT conducted to assess a medication against a placebo can be undertaken relatively simply and at low cost on large numbers of patients. Conversely, an immediate implant loading study would require higher levels of procedural clinical competency at great cost. Additionally, the relatively low failure rates dictate large numbers of patients in a controlled study for adequate statistical validity. Furthermore, the large number of variables demand a considerable number of RCTs resulting in fiscal requirements that would be prohibitive. Similarly of interest to practising dentists is the example of an immediately loading protocol having a success rate of 100 per cent in a multicentre study.[29] Does this need to be tested against a control and what is to be achieved? Of course the study could just include ideal patients and introduce other levels of bias, but the inclusion criteria for most immediate loading studies are implicit and form a basis for clinical guidelines anyway. Some systematic reviews and meta-analyses were attempted but failed because of heterogeneity and overall poor quality of the selected trials. The resultant fallback is a narrative review that covers a very small percentage of the available literature in an extended and complicated way to provide a vague and uninformative conclusion. We have therefore adopted the position that

Fig 5. Patient 5. (a) Pre-treatment view of missing 24. (b) Implant placement and titanium temporary abutment. (c) Provisional screw retained acrylic resin crown. (d) Provisional crown 3 months. (e) Clinical view 4 years, screw retained porcelain fused to gold abutment crown. (f) Periapical radiographic view 4 years.

it is possible to be more realistic to provide information relevant to the practising clinician.

Success with immediate loading is related to the key issues of primary implant stability, an osseoconductive implant surface responsible for the development of enhanced secondary implant stability, and controlled functional loading of the implant interface. None of these parameters have been adequately evaluated in controlled RCTs and in fact such studies may well place control groups of patients at a disadvantage and hence raise ethical questions. The evaluation of implant stability is one such controversial area. Insertion torque

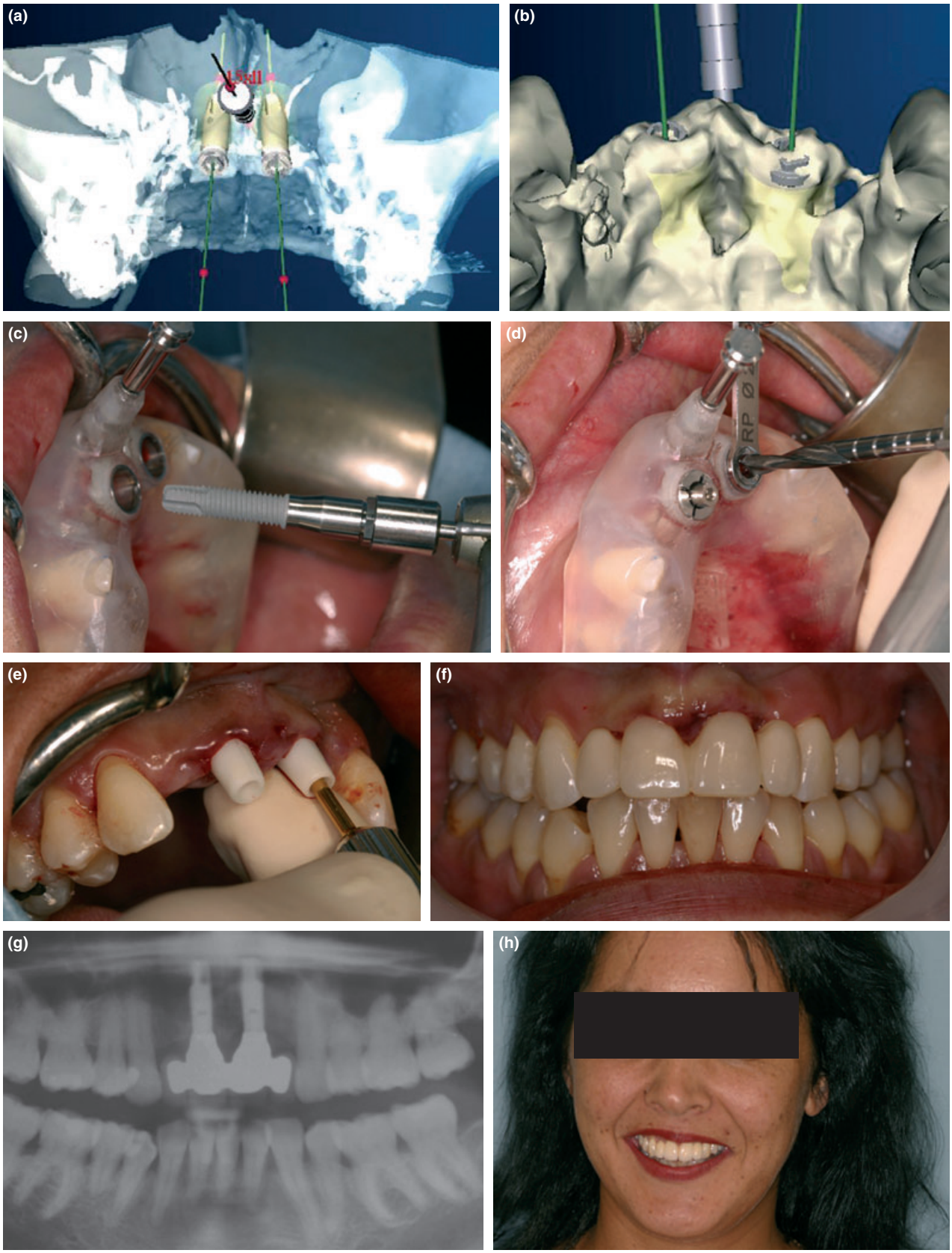

Fig 6. Patient 6. (a) Software planning for implant placement anterior maxilla, labial view. (b) Software planning for implant placement anterior maxilla, palatal view. (c) Implant installation sequence. (d) Instrumentation sequence through anchored surgical template. (e) Surgical template removal and zirconia abutment placement. (f) Placement of provisional acrylic prosthesis, SVT. (g) Panoramic radiograph 2-year follow-up, zirconia abutments and prosthesis. (h) Aesthetic outcome, 2-year postoperative follow-up.

values and resonance frequency analysis provide important information on implant stability and implant outcome, and both primary and secondary failure.[28] The correlations of these measurements with pre-evaluated bone quality are important for future treatment planning, but are not of themselves absolute. It has been emphasized that especially for resonance frequency measurements, the follow-up over time is important to make correlations with implant outcome.[28]

The Brånemark research was carried out using implants of 3.75 mm diameter and 7–10 mm length.[1] Long-term outcome reported high success rates using a two-stage surgical approach with delayed loading because these implants were osseointegrated when loaded. However, careful consideration of the occlusal scheme was emphasized to ensure long-term predictable functional outcomes. Immediately loaded implants are not osseointegrated although some authors have claimed[7] otherwise and stability at insertion is relatively a much more critical issue. Accordingly, experienced clinicians believe that in immediate loading the use of longer implants, particularly bone engaging cortical, is a more significant consideration than in 2-stage protocols or delayed loading situations.

The patient cases described employed implants with enhanced surface microstructure in all cases from 2000 onwards, following the introduction of an oxidized surface. The earlier cases used implants with the classical machined surface. Whilst very high success rates were evident in both cases, the literature search supports the contention that modified surfaces are an integral part of immediate loading protocols at the present time.

The question of minimal numbers of implants used to achieve a predictable and successful outcome has not been evaluated in RCTs but is important if the goal is to make treatment more affordable. A case in point is the outcome of a recent study that concluded that the immediately loaded, single implant-retained mandibular overdenture, using an oxidized surface implant is a viable treatment proposition for selected patients. The report suggested that this protocol may be considered to be the entry level treatment for rehabilitation of the edentulous mandible in selected patients, especially the underprivileged geriatric groups.[24]

The occlusal management of full-arch implant prostheses is different from single tooth or partially endentulous implant restorations. Full-arch designs benefit from cross-arch stabilization in eccentric excursions, whereas partially edentulous restorations are left in light centric contact and free of eccentric contact wherever possible during the provisionalization phase. In all cases, careful instruction is given to reduced functional capability and soft dieting during the six-week period postoperatively. A biomechanical rationale to decrease the initial risk of overload is reasonable because implant failure and overload has been well established.[8] Forces may be influenced by patient factors, implant position, cantilever forces, occlusal load direction, occlusal contact intensity and diet. The surface area of load distribution may be increased by implant size, implant design, and surface condition of the implant body. A blend of these factors affect the amount of stress at the developing implant interface and hence may affect the risk if immediate occlusal loading is utilized.

Marginal tissue response and aesthetic outcome is an area of significant uncertainty. Many clinicians support the contention that soft tissue aesthetics is improved with immediate than with a delayed approach or healing abutment if the initial tissue contours are ideal.[11] The implants shown in Fig 5 are of a scalloped design. The concept of a scalloped implant platform appears to be sound, even though this current implant design could be enhanced.[29] With better understanding of bone physiology as it relates to implant geometry and surface, it is hoped that implant design can be further developed to maintain the peri-implant tissues.

Guided surgery is an exciting development which also falls into the category of being undocumented with RCTs, and has only been reported in one multicentre study.[25] However, it is experiencing wide clinical acceptance as a modality for various clinical applications rather than as a single application for immediate loading. The first level of application can be at the diagnosis and treatment planning level for evaluation. Improved software planning programmes can also be used to evaluate bone density and other parameters pertinent to immediate loading. The next level can be for the production of precision surgical templates to more accurately and predictably install implants after which surgical impressions and traditional protocols are employed for prosthesis fabrication. The third level is to additionally pre-produce the prosthetic solutions for SVT. Thus the utilization of the software planning has flexibility for the clinician. At the present time most of the sparse literature is pertinent to the edentulous jaw. Only one paper reports outcomes for partially edentulous application and shows similar results to those achieved with conventional two-stage delayed loading protocols at the two-year follow-up period.[30]

Today implant supported restorations are a realistic treatment option in the delivery of care for partial or total edentulism. Delayed loading has been evaluated extensively over the last 25 years and is reasonably well documented. However, the shortfall in evidence base and lack of appropriate RCTs suggests that much of what we do today is based on accumulated clinical experience rather than well designed and appropriately documented research. While immediate loading is emerging as a worthwhile and attractive alternative, the risk/benefit ratio must be assessed for individual

patients and in selected cases only. The greater the benefit and the lower the risk assessment, the more likely immediate loading can be the appropriate treatment.

CONCLUSIONS

There is an emerging need and demand for immediately loaded treatment solutions in the management of partial or total edentulism. However, the literature is inconclusive and inadequate with respect to providing a sound evidence base on which clinicians can rely to make an informed decision. Consequently, most current recommendations are based on multicentre investigations and accumulated clinical experience rather than RCTs. While the early results of carefully developed protocols are encouraging, the immediately loaded alternative must be considered on an individual basis and in selected cases only. Clinicians need to be ever vigilant that enthusiasm does not cloud good judgement.

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