The present day status of dental implants

Toby R. Talbot MSD, BDS, FDS RCS

Dental implants are a means to offer anchorage to an overlying prosthesis in the partial or totally edentulous patient. The implant offers a method of actual ridge augmentation similar to bone grafting. Relative ridge augmentation procedures would include vestibuloplasties and mylohyoid ridge reductions. Much in the same way that we prepare a dentition to receive a removable partial denture using guide planes and rests seats, even in the totally edentulous situation mouth preparation still needs to be considered.

The function of ridge augmentation is to improve the stability of the prosthesis by inhibiting lateral movement. It follows, therefore, that the only indication for ridge augmentation procedures is that select group of patients who complain specifically of denture movement during function, which may or may not be associated with soreness. This is associated with excessive tongue or lip activity, e.g. singers, public speakers and wind instrument players. This failure to satisfy the functional demands of the patient when all other conventional forms of treatment have failed indicates a need for ridge augmentation. I use the adjective 'conventional' with caution as modified procedures may utilize functional impression techniques, processed soft liners and alternative occlusal schemes, e.g. cuspless teeth.

It is the severely atrophic edentulous mandibular ridge which poses the greatest problems to the prosthodontist. The difficult decision, which relies solely upon clinical judgement, is the method of ridge augmentation.

If an implant is the selected choice, the prosthodontist may prescribe a subperiosteal, endosseous, transosseous, endodontic, intramucosal insert or placement of non-resorbable hydroxylapatite. Implants may be further subdivided into complete, terminal or intermediary. The complete implants are utilized in the totally edentulous situation. The terminal and intermediary implants simply describe their position in the arch in relation to any remaining natural teeth.

In addition to failing to satisfy the patient's functional demands, patient selection for implants necessitates strict criteria. Some patients require the emotional confidence that their prostheses will not become unseated and cause social embarrassment, whether this is a real or apparent fear. These patients, whose demands are primarily due to emotional reasons, so often form a large bulk of the patients requesting implants. However, it is obviously essential that these patients are assessed extremely carefully, as underlying anxiety, depressive and inadequacy states makes them poor candidates. Emotionally unstable patients make very poor implant patients. It is not uncommon for anxious patients to exhibit parafunctional activity which adds considerable stresses to the

implant. If excessive, these activities contraindicate implants. Patients who have a history of depressive illness tend to be unreliable regarding homecare and maintenance of the implants and prostheses. Patients with a history of alcoholism, similarly, are unreliable and should not be selected for implants.

These criteria obviously form a rather sensitive subject. The use of the Cornell Medical Index can be of enormous help. It takes approximately 20 minutes for the patient to complete the questionnaire. A rapid insight into the patient's emotional status in addition to the general medical history is obtained. I have found this approach considerably more reliable than 'gut-feelings'.

The general medical status of the patient must be evaluated carefully. Absolute contraindications for implants include endocrine disorders, including controlled diabetes. It has been the experience of several workers in the field of implantology that even apparently well controlled diabetics occasionally become uncontrolled, and tissue response can be poor in relation to implants. Nutritional deficiency states must be ruled out and routine serum iron, vitamin B_{12}, folate and vitamin C levels must be assessed, in addition to a dietary analysis. Osteoporosis is an absolute contraindication. Unfortunately, it is particularly common in post-menopausal women, who form the main bulk of those patients in the prosthodontist's practice exhibiting marked resorption of the residual mandibular ridge. Immunodeficiency states, including all patients on long term steroid therapy, are absolute contraindications. The presence of mucosal or bone infection must be resolved before the placement of an implant. Retained roots, bony spurs and hyperplastic tissues must all be dealt with before surgery. Even the presence of amalgam tattoos can complicate implantology. There have been recorded situations where there has been generalized erythema involving the oral tissues in association with the placement of a titanium alloy implant in the presence of an amalgam tattoo. Once the amalgam tattoo was excised, resolution of the generalized erythema resulted. This was attributed to the galvanic action that occurred between the various dissimilar metallic ions present. The presence of an opposing natural dentition is a relative contraindication due to the higher stresses that can be placed upon the implant. In my own experience, I have found that if there is no evidence of parafunctional activity, and if balanced occlusion can be obtained with the prosthesis—by selective grinding or reconstructing the opposing natural dentition—then satisfactory results can be obtained. This situation is not uncommon with patients who present having lost all their mandibular teeth and retained most of the maxillary dentition.

■ SUBPERIOSTEAL IMPLANTS

The first practical subperiosteal implant was reported in 1948 and further developments can be attributed largely to Dr Roy Bodine at the University of Southern California. The technique involves two surgical procedures. The first is to obtain an impression of the exposed residual bony ridge, and the second is to place the custom made implant into position. Originally, the techniques involved a time interval of between 2 and 3 weeks

between the bone impressions and delivery of the implant. More recently, techniques have been developed to deliver the final implant only 32 hours after obtaining the bone impressions.

The treatment begins with the construction of conventional dentures to the wax try-in stage. An over-extended impression is also made to produce three duplicate casts to fabricate an acrylic resin abutment locator, a bone impression tray and a bone occlusal rim. The abutment locator will locate the position of the transmucosal posts. Mucoperiosteal flaps are raised and the bone impression is made, utilizing the customized tray. The bone occlusal rim is used to relate the mandible to the maxillary wax trial denture. The impression is poured to produce the working cast. If alveolar resorption has been marked, it is not uncommon to find bony fenestration with the inferior dental alveolar nerve on the superior surface of the mandible. Wax relief is placed on the cast in this area before duplication to produce a refractory cast.

The working cast is mounted on an articulator against the maxillary trial denture, utilizing the occlusal rim. The positions of the abutment posts are marked using the locator and the design of the implant substructure is drawn on the working cast. A peripheral frame is outlined, approximately 2½ mm wide buccally and lingually, connected to the abutment post with primary struts, and secondary struts are drawn for additional strength. This information is then transferred to the refractory cast, waxing up the substructure, and the abutment posts are orientated, using the opposing maxillary wax trial denture. Sprues are attached and the wax-up invested and subsequently cast using a cobalt–chromium alloy. The patient is then scheduled for placement of the substructure following re-exposure of the bony ridge. Following placement of the implant the old denture is modified and relined with a tissue conditioner and related to the transmucosal posts. The construction of the definitive prosthesis can be begun 2 or 3 weeks later. The subperiosteal implant has been used in both the total and partial edentulous situation. Longitudinal clinical follow-up studies of the subperiosteal implant in the total edentulous state have been conflicting. Bodine followed up 27 implants after 15–22 years of service and found 96 per cent were still in function at 5 years and 67 per cent at 10 years (Bodine, 1974; Bodine et al., 1970, 1976, 1977). Others have reported figures for 46 per cent and 39 per cent in comparison. Inadequate numbers of subperiosteal implants in the partially edentulous state preclude any statistical evaluation. Follow-up studies involving maxillary subperiosteal implants have not been encouraging. *Figure* 1 shows an implant after 15 years.

■ ENDOSSEOUS IMPLANTS

Endosseous implants have evolved into various forms, involving spiral, blade and vent shapes, utilizing many materials, including metallic alloys, vitreous carbon, bioglasses and ceramics. Metallic alloys include cobalt–chromium, stainless steel, titanium and its associated alloys. The majority of these implant techniques offer off-the-shelf systems, therefore avoiding the

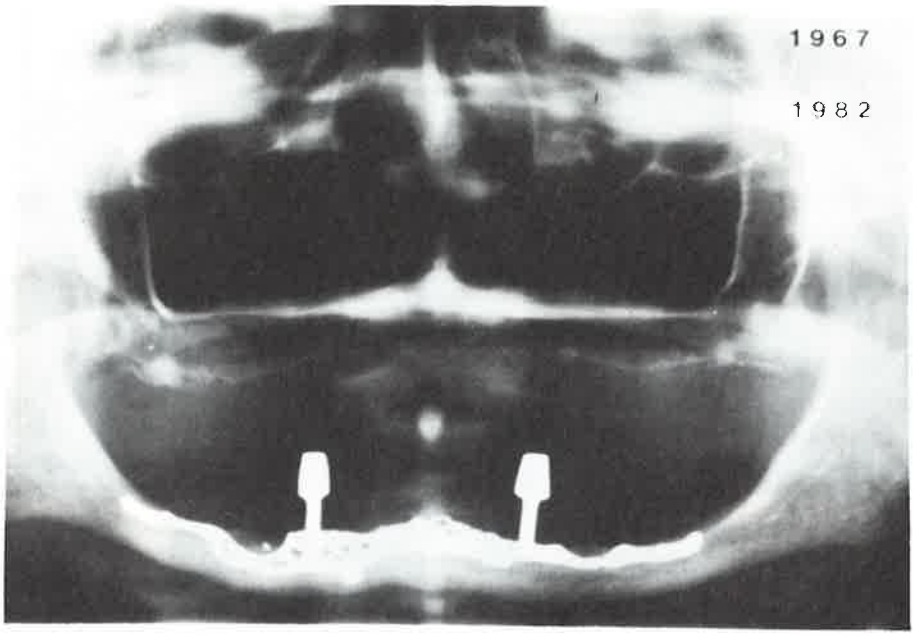

Figure 1 Radiograph of subperiosteal implant 15 years after insertion. Courtesy of Dr N. Berman, Private Practice, Seattle, Washington, USA.

necessity for detailed customization, as is necessary with the sub-periosteal implant. In the majority of techniques only one surgical procedure is required. This has its attractions due to simplicity.

The blade endosseous implants have been developed by Linkow (1974), offering a multitude of various shapes that can be utilized in various parts of the jaw. Mucoperiosteal flaps are raised, a groove in a mesial-distal direction is prepared in the jaw, and the appropriate implant, which can be adjusted by reduction and/or bending, is tapped into place. After soft tissue closure, the provisional prosthesis is relined with acrylic resin.

Blades have been utilized in the total and partial edentulous situation. However, inadequate numbers of the latter preclude statistical evaluation. One investigator reporting on a longitudinal clinical study of 200 blade implants gave a 5-year survival rate of 90 per cent. However, other investigators have produced a survival rate of 65 per cent in comparison. *Figure* 2 shows an intermediate blade implant.

Another example of an endosseous implant is the osseointegrated fixture developed by Brånemark et al. (1969) in Gothenburg, Sweden (*Figure* 3 and 4). These screw-like cylinders are made of the purest available titanium with dimensions of approximately 10 × 4 mm. Between four and six fixtures are placed in the anterior aspects of the maxilla and mandible, following the

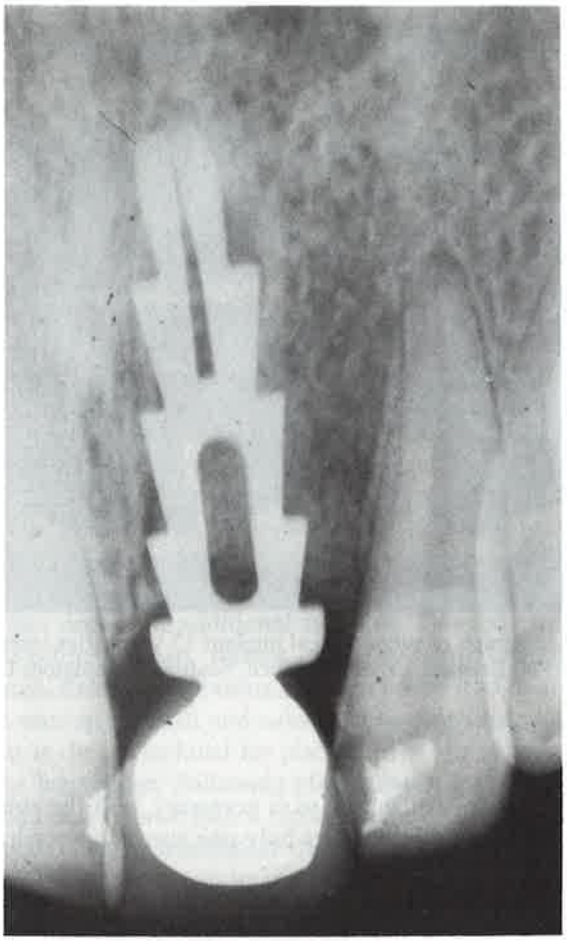

Figure 2 Radiograph of an intermediate blade implant 5 years after insertion. Courtesy of Prof. J. A. Hobkirk, Department of Prosthetics, Eastman Dental Institute, London.

reflection of mucoperiosteal flaps. Underlying structures, such as the nasal cavities, the maxillary sinuses and the mental nerves, are avoided. Round and spiral burs at slow speed prepare the sites initially, using saline as a coolant. A tap is then used to prepare a thread in the site and the fixtures are threaded into place. A cover screw is placed and the wound is closed. After 1–2 weeks, when the sutures have been removed and initial healing has taken place, the existing complete dentures are relined using tissue conditioner. These are worn for between 3 and 6 months.

According to research carried out by Bränemark et al. (1977), this period of non-function allows the osseous tissues to integrate themselves intimately to the

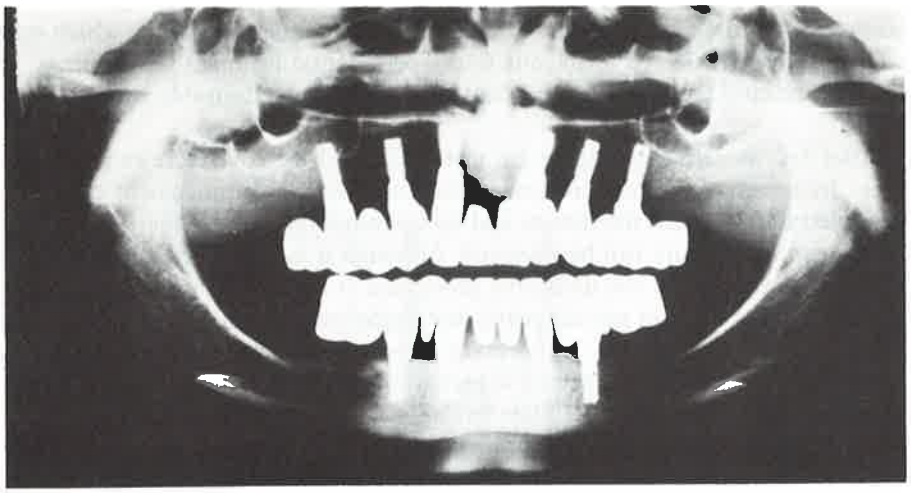

Figure 3 Radiograph of osseointegrated fixtures in an edentulous patient. Courtesy of Prof. P.-I. Brånemark, Institute for Applied Biotechnology, Gothenburg, Sweden.

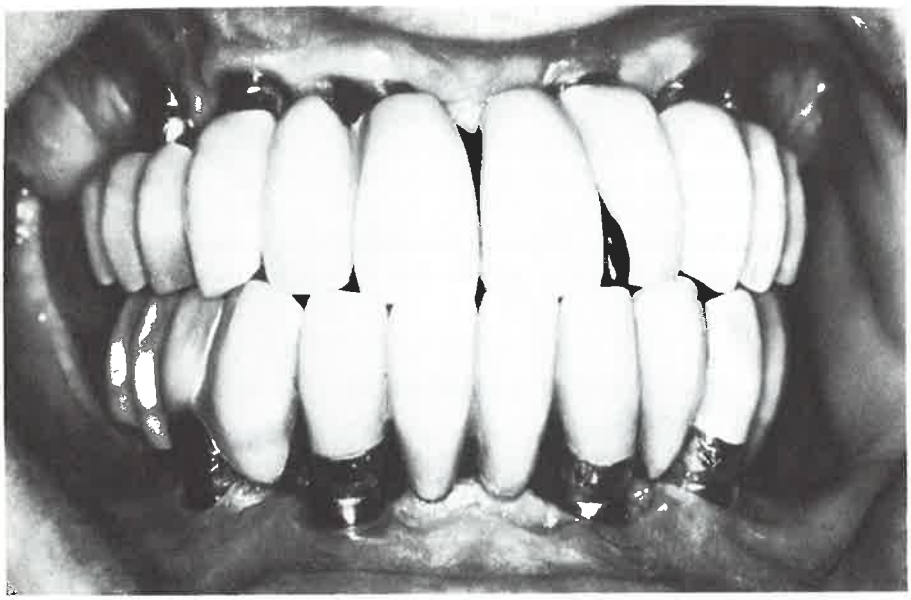

Figure 4 Clinical appearance of fixed prostheses using osseointegrated fixtures for anchorage. Courtesy of Prof. P.-I. Brånemark, Institute for Applied Biotechnology, Gothenburg, Sweden.

surface of the titanium fixtures. The peri-implant connective tissue, which other workers have considered analagous to the periodontal ligament intervening between natural teeth and bone, is not considered to be desirable by Brånemark et al.

After 3–6 months the fixtures are uncovered and the cover screws removed. If these fixtures have become integrated then no discernable movement can be demonstrated between the fixture and its surrounding bone. If there is any movement, the fixture can be removed. Although it is desirable to have six fixtures supporting the definitive prosthesis, it has been found that four osseointegrated fixtures are adequate, and therefore the loss of one or two fixtures is not of paramount importance. However, if it is felt necessary to replace one or two of the fixtures, a period of 6 months can be given for bone regrowth in the socket and another fixture placed at that time. After osseointegration has been achieved abutment collars are attached to the fixtures and then the procedures necessary for the construction of the definitive prosthesis can be carried out. It is unnecessary for the fixtures to be inserted parallel to one another, as the abutment collars have internal threads to allow the framework of the prosthesis to be connected with screws. Initial work by Brånemark et al. (1969) involved using conventional bridge-type designs with gold alloys and porcelain. More recently, Zarb and Symington (1983) in Toronto have utilized a silver–palladium framework and an overdenture type prosthesis with acrylic resin teeth. The prostheses are faculatively removable by the prosthodontist to facilitate monitoring at the recall appointments.

Since 1965, Brånemark et al. have placed in excess of 4000 fixtures. Ten-year longitudinal clinical studies have resulted in 81 per cent of fixtures placed in the maxilla being retained, and 91 per cent of mandibular fixtures being retained. These in fact are individual fixtures and this failure rate has resulted in the retention of 94 per cent of the maxillary prostheses, and 100 per cent of the mandibular prostheses. As I have previously mentioned, the loss of one or two individual fixtures does not necessarily mean the loss of the overlying prosthesis. The differences between the maxillary and mandibular fixture success rates has been attributed to the difference in bone density between these two different sites.

■ TRANSOSSEOUS IMPLANTS

A particularly promising example of this type of implant is the staple implant (*Figures* 5 and 6) made of titanium, developed by Dr Irwin Small (1975). This consists of a bone plate with three or five retaining posts and two transosseous posts welded to the plate. The implant was designed solely for the residual mandibular ridge and involves a submental approach to the inferior border of the parasymphysis of the mandible. Parallel holes for the retaining and transosseous pins are prepared using a drill guide attached to the exposed mandible and an acrylic resin template placed over the residual mandibular ridge intraorally. The staple comes in three sizes with either five or seven pins.

Figure 5

Figure 6

Figure 5 Staple implants available: seven, modified seven and five pins.

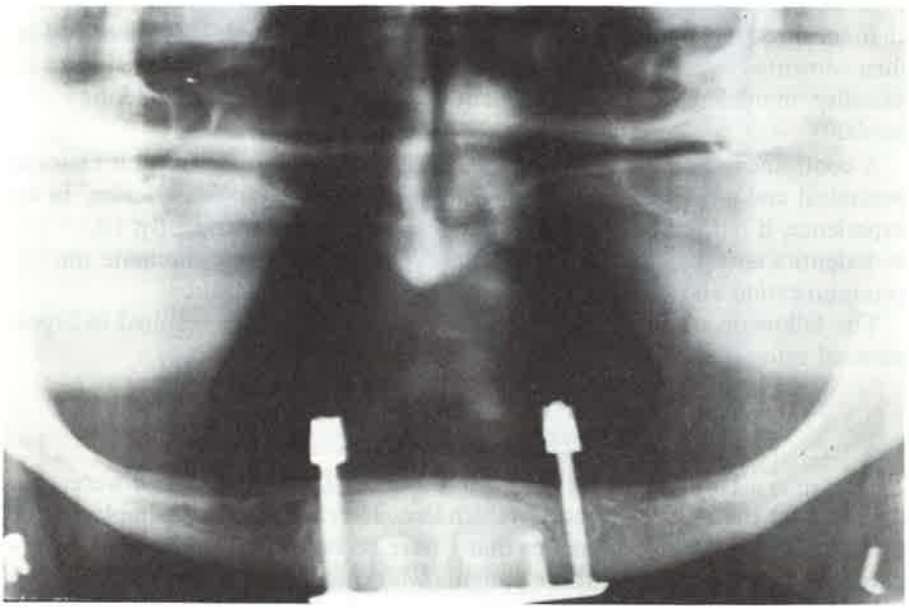

Figure 6 Radiograph of staple mandibular implant in situ.

The transosseous pins must be a minimum of 3 mm medial to the mental foramen to avoid damage to the neural bundles. The staple is malleted into position with the transosseous pins entering the mouth through the crest of the residual ridge. The pins ultimately act as abutments for an overlying mucosal-borne prosthesis, utilizing resilient precision attachments.

Longitudinal clinical studies, using peer review, clinical appearance, radiographic examination and patient evaluation as parameters, have been carried out in staple implants that have been in situ for between 1 and 10 years. Eighty-six per cent of the implants were still functioning, associated with tissue health. Subsequent studies involving 250 implants with post-insertion periods varying between 6 months and 7½ years have resulted in 96·8 per cent retained implants associated with healthy tissue. The lower success rate recorded in the initial study by Small (1975) can be explained by the fact that the earlier staple implants were originally three- and four-pinned varieties made of stainless steel. In later development work by Small (1979), the titanium implants with five and seven pins were used and the success rate of these has been in excess of 90 per cent.

■ ENDODONTIC IMPLANTS

Endodontic implants have been developed with cobalt–chromium and titanium alloys in the form of smooth and screw-shaped rods. The indication for their use is loss of root structure resulting in unacceptable or progressively increasing mobility, commonly associated with root fractures or resorption. Following endodontic therapy, specially designed reamers are used to prepare a channel through the root into the bone. A matched endodontic implant rod is then cemented into place. This improves the crown root ratio and reduces mobility, immediately following cementation. *Figure* 7 shows endodontic implants.

A contraindication for their use commonly given is communication between a periapical and a marginal periodontal lesion, an endo-periodontal lesion. In my experience, if both pathological processes are treated independently, i.e. endodontics and periodontal theory, ultimate resolution may eliminate the communication and the endodontic implant may still be useful.

The follow-up studies involving endodontic implants have resulted in 5-year survival rates of greater than 90 per cent.

■ INTRAMUCOSAL INSERTS

These implants were introduced by Dahl in 1943 and were designed for the maxillary complete denture. They are the most simple and least invasive of all implant techniques that I have become involved in. They are particularly well suited for those patients who complain of severe gagging in association with their complete dentures, to produce a horseshoe maxillary denture, and for singers who have complained of loss of denture retention

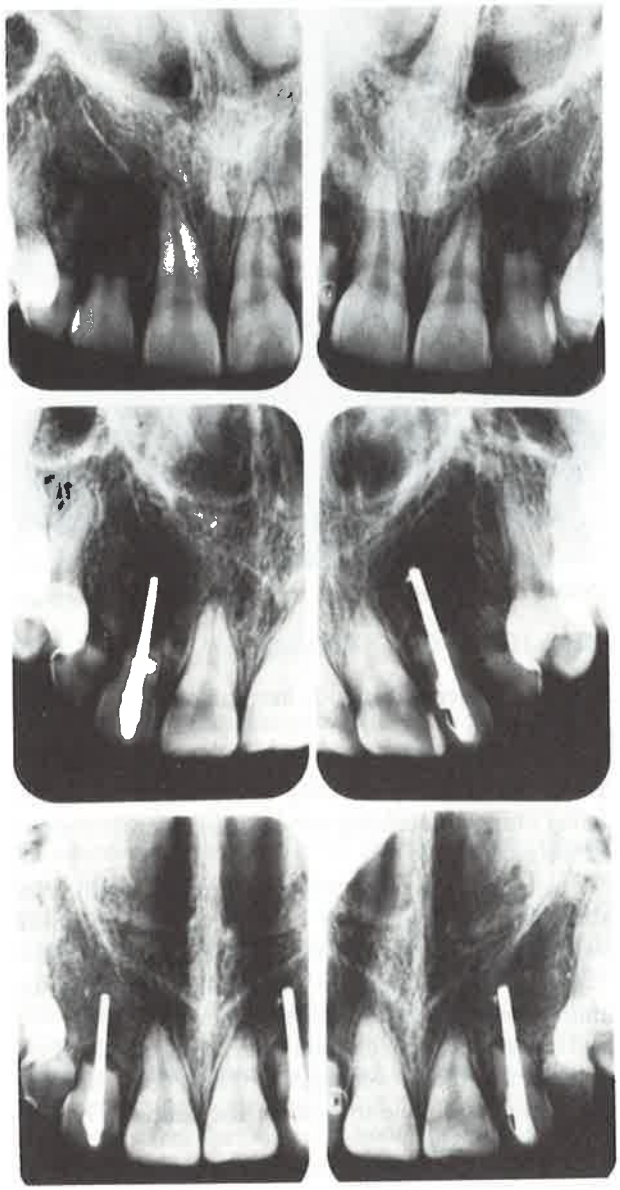

Figure 7 Radiographs of root resorption affecting lateral incisors due to unerupted canines (surgically removed). Endodontic implants at 5 and 11 months after insertion. Courtesy of Dr B. G. N. Smith, Department of Conservation, Guy's Dental Hospital, London.

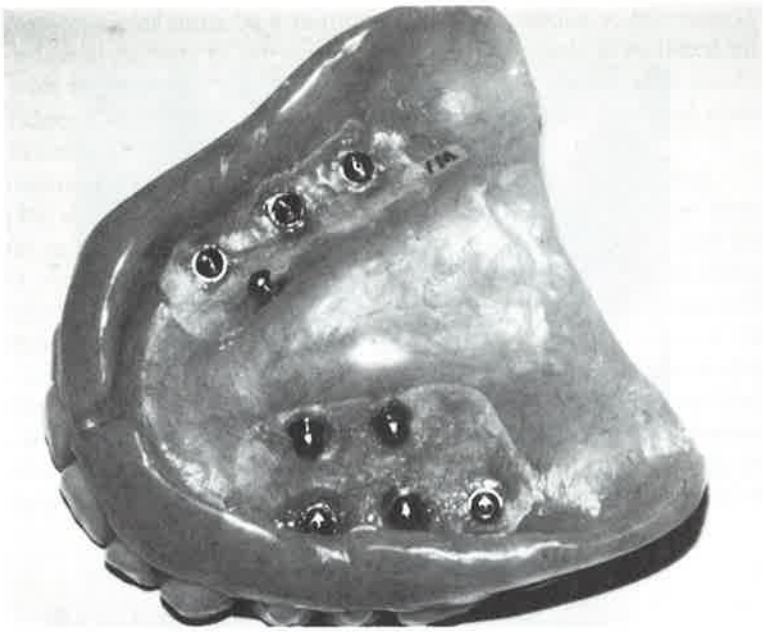

Figure 8 Maxillary complete denture with intramucosal inserts attached.

during some of their exaggerated mouth movements. *Figure* 8 shows a complete denture with these inserts.

They consist principally of small metal nipples which can be incorporated into the denture base at the time of processing or related to the denture base directly in the mouth using autopolymerizing acrylic resin. Between eight and twelve inserts are used for a denture.

At the time of insertion, the insert sites are prepared with a trephine and the denture is retained using sutures. After 10 days, the prosthodontist removes the denture, irrigates the mouth and then instructs the patient on the method of insertion and removal. I have found the use of water irrigating devices a great help in maintaining the hygiene of the insert sites.

The only disadvantage of the technique that I feel, is that the patient is unable to leave the denture out overnight. If this is done, the insert sites rapidly contract and the patient is unable to reinsert the denture. This then necessitates repreparation of the insert sites.

■ PLACEMENT OF NON-RESORBABLE HYDROXYLAPATITE

This ceramic material has physical and chemical properties similar to bone. The material is placed subperiosteally. Vertical incisions are made in the sulcus adjacent to the midline of the maxilla and the canine regions of the

mandible. The periosteum is tunnelled to create a pocket for the material. The material, in particle form, is mixed with the patient's own blood, to act as a vehicle, and syringed into the created space. In cases of considerable ridge resorption cancellous bone chips are mixed with hydroxylapatite, although whether this is necessary has yet to be evaluated. After placement, the ridges are manipulated to form the desired contour. Maxillary procedures require a stent to be placed for 3 weeks to maintain the desired contours. This has not been found necessary with the mandible. The material is used to increase ridge height in addition to eliminating unwanted undercuts. Definitive prosthodontic procedures are begun 3 weeks after placement.

Follow-up studies have been limited due to the recent introduction of the technique. Kent et al. (1983) followed up 56 patients out of an original 76, 1–4 years after implant placement. Parameters evaluated included the clinical appearance, radiographic examination, prosthodontic and patient assessment. Approximately 90 per cent of patients exhibited very good results. Computer analysis of serial radiographs revealed a 10 per cent loss of ridge height in the follow-up period. This compares extremely well with the recorded 60 per cent loss associated with augmentation procedures using autogenous onlayed bone grafting alone, in comparable follow-up periods.

It will be interesting to wait the results of further follow-up of these patients.

■ THE PROBLEMS ASSOCIATED WITH DENTAL IMPLANTS

My selection of the examples of each implant type that I have described has not been empirical. The ultimate assessment of any treatment modality is the longitudinal clinical study following up groups of patients similarly treated to assess the ultimate success rate, preferably at 5 and 10 year intervals. As well as assessing the long term outcome of our treatment we are then able to offer a figure to our patients; a length of service prediction. We can then, together with our patients, balance the risks against the potential gain. Except in the case of the intramucosal inserts, about which I could find no longitudinal study, some attempt has been made to observe all the other implants that I have described over varying periods.

There still, however, remain considerable problems. One is the criteria for success. Some workers consider success as any implant still in function when the patient dies, some workers consider there is no complete failure as all implants give some service. Others feel that success should be judged by the patient and not the clinician. The presence of pathology, following radiographic examination or clinical examination, may be the criteria for failure. Some workers consider radiographic evidence of bone loss without symptoms is a success, whereas others will consider it unsuccessful. It is these differences of opinion between clinicians that have understandably resulted in wide differences in claimed success rates between workers using the same treatment modality. In addition there are a lack of objective indices, resulting in quite conflicting reports.

Criteria such as bone loss, gingival health, pocketing and mobility are difficult indices to repeat in the field of periodontology, let alone in the field of implantology. Bone loss assessment requires reproduceable radiographic techniques. Pocketing may be difficult due to the shape of the overlying abutments, making it impossible to pass a periodontal probe parallel with the transmucosal implant neck. Mobility assessment is impossible with a one-piece casting or where the superstructure of the prosthesis is not removable. Above all, it has not been determined whether the indices that we use in periodontology actually are of any clinical relevance with respect to implantology. In addition, we cannot ignore all subjective criteria, such as function, comfort and the patient's emotional attitude towards the implant. One of the most important recent developments in dental implantology has been the Harvard Consensus Conference that took place in 1978. This conference resulted in various recommendations made by the workshop panels. A definition of success in implantology was agreed upon, involving both subjective and objective criteria. Guidelines for the current use of various implant types and patient selection were made. Complications and criteria for the removal of implants were stated, and the necessity for informed consent for the patient was emphasized. Of particular importance are the questions: why is the procedure necessary? What benefits can be expected? How long can they be expected to last? Above all, what alternative forms of treatment are available? Basically, the implantologist must justify his treatment modality. The workshop elucidated evaluation criteria with respect to mobility, bone loss and gingival health. Future guidelines included the necessity for further longitudinal studies that were all well controlled, using peer review, tight patient selection criteria, uniform data and evaluation methods, and the need for more scientific research in the domain of dental implantology. the works of Small and Bränemark have been most thorough.

Dental implantology is an exciting field. Attention to detail, motivation of patients, and constant monitoring of their progress is essential. I am so often faced with the totally edentulous patient who has arrived in that sad state after years of self-neglect, and it is quite unreasonable to earmark all these patients for implants because so many of them will continue to neglect themselves as they have done in their lives beforehand. It is equally frustrating when I am faced with the post-menopausal woman who presents with marked resorption of the mandibular ridge. She is one type of patient that I am quite unable to help with dental implants. She is more likely to be suffering from generalized osteoporosis; in my experience tissue response is poor, and there are often strong emotional overtones to many of these patients' problems. Other approaches including dietary advice, and modified conventional approaches using functional impressions and processed soft liners in addition to a great deal of tender loving care have proved in my hands to be considerably more satisfactory, but admittedly not totally successful.

There are, however, those few highly active and healthy individuals who are dissatisfied with their conventional prostheses. Their functional demands are

very high, and their dentures cannot be improved upon. It is this special select group that may be considered for an implant. It is solely the prosthodontist's responsibility for their prescription.

References

Bodine R. L. (1974) Evaluation of 27 mandibular subperiosteal implant dentures after 15–22 years. *Journal of Prosthetic Dentistry* **32**, 188.

Bodine R. L. et al. (1970) Implant denture histology: gross and microscopic studies of a human mandible with a 12 year subperiosteal implant denture. *Dental Clinics of North America* **14**, 145.

Bodine R. L. et al. (1976) Long-term implant denture histology and comparison with previous reports. *Journal of Prosthetic Dentistry* **35**, 665.

Bodine R. L. et al. (1977) The subperiosteal implant denture program at the University of Southern California—Parts I, II, III and IV. *Oral Implantology* **6**, 351; **7**, 11, 193 and 375.

Branemark P.-I. et al. (1969) Intra-osseous anchorage of dental prostheses. *Scandinavian Journal of Plastic and Reconstructive Surgery* **3**, 81.

Branemark P.-I. et al. (1977) Osseointegrated implants in the treatment of edentulous jaw. Experience from a 10 year period. *Scandinavian Journal of Plastic and Reconstructive Surgery* **11**(Suppl. 16).

Kent J. N. et al. (1983) Alveolar ridge augmentation using non-resorbable hydroxylapatite with or without autogenous cancellous bone. *Journal of Oral and Maxillofacial Surgery* **41**, 629.

Linkow L. I. (1974) Statistical analyses of 173 implant patients. *Oral Implantology* **4**, 540.

Small I. A. (1975) Metal implants and the mandibular bone plate. *Journal of Oral Surgery* **33**, 571.

Small I. A. (1979) Use of the mandibular staple bone plate in the deformed mandible. *Journal of Oral Surgery* **37**, 26.

Zarb G. A. and Symington J. M. (1983) Osseointegrated dental implants: Preliminary report on a replication study. *Journal of Prosthetic Dentistry* **2**, 271.