Patient assessment and diagnosis in implant treatment

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ABSTRACT

As in any dental treatment procedure, a thorough patient assessment is a prerequisite for adequate treatment planning including dental implants. The literature was searched for references to patient assessment in implant treatment up to September 2007 in Medline via PubMed and an additional handsearch was performed. Patient assessment included the following aspects: (1) evaluation of patient's history, his/her complaints, desires and preferences; (2) extra-and intra-oral examination with periodontal and restorative status of the remaining dentition; (3) obligatory prerequisites were a panoramic radiograph and periapical radiographs (at least from the adjacent teeth) for diagnosis and treatment planning. Additional tomographs are required depending on the anatomic situation and the complexity of the planned restoration; (4) study casts are needed especially in more complex situations also requiring a diagnostic set-up, which can be tried-in and transferred into a provisional restoration as well as into a radiographic and surgical template. The current review clearly revealed the necessity for a thorough, structured patient assessment. Following an evaluation, a recommendation is given for implant therapy or, if not indicated, conventional treatment alternatives can be presented.

Key words: Dental implants, patient assessment, implant indication.

Abbreviations and acronyms: ASA = American Society of Anesthesiology; BON = bisphosphonate-associated osteonecrosis; FDP = fixed dental prostheses; OVD = occlusal vertical dimension; RDP = removable dental prostheses; VAS = visual analogue scale.

INTRODUCTION

When considering implant treatment in a particular case, the practitioner has to evaluate whether oral implants are indicated: (i) for this particular patient; (ii) in this specific oral situation; and (iii) within the framework of a comprehensive reconstructive treatment planning. During the last decade the use of implants has widely spread among practitioners with increasing demand from patients and heavy marketing by the companies. However, reports about alarming implant failures are emerging in the literature which are mainly related to implant malpositioning as a result of poor treatment planning.[1] In addition, the number of late implant failures associated with peri-implantitis is increasing. Since peri-implantitis is caused by microbial biofilm, and patients with a periodontal history are at higher risk, patient selection, personal oral hygiene and professional maintenance become important factors when trying to determine from the outset an optimized prognosis for a particular patient. The increasing number of malpractice lawsuits[2] means a thorough evaluation of patient history and an awareness of the risk of treatment failure and complications is required as implant treatment outcomes are not as predictable as that of the conventional therapies with fixed (FDP) or removable dental prostheses (RDP), particularly in circumstances where aesthetic considerations are the overriding concern. The application of a systematic patient assessment and a straightforward diagnostic planning procedure facilitates an optimal treatment recommendation and helps to avoid failures and complications.

In the following review the current literature has been examined in order to analyse the available evidence on patient assessment for implant treatment. Special consideration is given to three typical situations: single tooth replacement, partial endentulism and edentulous jaws.

Literature search strategy

The literature was searched for references to patient assessment in implant treatment up to the end of September 2007 in Medline via PubMed. An additional handsearch of references in the retrieved articles was

performed and the first author's own research material and personal collection of relevant publications were used for the analyses. The PubMed search was restricted to articles published in 2000 or after. The keywords used in the database search were "patient assessment" and "dental implants" retrieving 222 references, as well as "dental implants" and "implant indication" and "diagnosis" leading to 28 additional references. Titles and abstracts of the selected articles were then all screened and considered for inclusion in the current review if the following criteria were met: (1) information concerning implant indications and contraindications; (2) information given on how to examine the implant patient; (3) information relevant to diagnostic techniques in the implant patient. Applying these inclusion criteria, full texts were examined from 20 articles retrieved from PubMed, and from 22 articles retrieved by handsearching. Of those, 20 references were selected for data extraction related to assessment and diagnosing of the prospective implant patient.

Patient's history and implant contraindications

During the first consultation, possible implant contraindications should be ruled out during the course of the examination. A medical questionnaire will aid in the initial interview and includes past and current diseases, temporary and long-term medication, smoking status and special dietary features. Additional questions address the age of any existing prosthesis and the presumed reason for tooth loss (caries, periodontal disease, trauma or others; Fig 1). Recurrent decay indicates a high caries activity, which might be — in addition to the required diet recommendations — a decisive factor as to whether to maintain or replace a questionable abutment tooth. Patients with a periodontal history are at higher risk for potential peri-implantitis leading to late implant failure.[3] This knowledge may also affect treatment planning. Anterior tooth loss following accidental trauma is frequently associated with advanced alveolar ridge defects and potential involvement of adjacent teeth has to be ruled out. In general, insufficient bone quantity for implant stabilization is no longer regarded as a contraindication due to the successful application of augmentation procedures using guided bone regeneration.[4] The additional effort, however, should be within reason and the patient must be willing to take upon him/herself the surgical burden especially when two-staged procedures with bone grafts from extra-oral sites are needed.

General contraindications for implant treatment are rare and mainly related to an increased risk for patients undergoing the surgical procedure, e.g., patients in poor general health, which could interfere with the surgical treatment and/or require medical

(a) Patient's history
— medical health status: ☐ healthy   ☐ medical advice required (use separate health questionnaire)
— increased risk for implant failure: ☐ yes   ☐ no
— reason for previous tooth loss: ☐ caries/decay   ☐ periodontitis/tooth mobility   ☐ trauma   ☐ others
— age of existing restorations: _____ years
— patient motivation/ability to provide home care: ☐ good   ☐ fair   ☐ poor
— patient expectation of therapy outcome: ☐ fixed   ☐ removable restoration
— palatal coverage acceptable: ☐ yes   ☐ no
— excessive gag reflex: ☐ yes   ☐ no
— phonation problems: ☐ yes   ☐ and related to existing restoration   ☐ no
— financial limitations: _____
— patient satisfaction with existing oral situation and restorations (filled out by the patient):

(b) How satisfied are you with the **restoration**:
Please, indicate your perception with a cross on the bar.

1. General satisfaction — very unsatisfied / average / very satisfied — 0 / 50 / 100 %
2. Retention and stability of the restoration — poor / average / very good — 0 / 50 / 100 %
3. Can you eat properly with the restoration (chewing ability)? Which food cannot be chewed? — poor / average / very good — 0 / 50 / 100 %
4. Is food getting caught underneath the restoration? — frequently / from time to time / never — 0 / 50 / 100 %
5. Do you have pain or soor spots with the restoration? — frequently / from time to time / never — 0 / 50 / 100 %
6. Esthetics, appearance — poor / average / very good — 0 / 50 / 100 %
7. Is your self-confidence affected? (Do you feel insecure with your teeth/the restoration?) — very insecure / not influenced / positively influenced — 0 / 50 / 100 %
8. Do you perceive the restoration as a foreign body? — foreign / not influenced / part of my body — 0 / 50 / 100 %
9. Do you wear the restoration during the whole day (day-time)? — not at all / from time to time / all time — 0 / 50 / 100 %
10. Do you wear the restoration at night?   yes ☐   no ☐

(c) Extraoral aspects
— facial proportions: ☐ correct   ☐ lower third too short (OVD reduced)   ☐ too long (OVD increased)
— facial symmetry: ☐ correct   ☐ occlusal/camper's plane left/right side too far cranial/caudal (*check*)
— facial/lip and cheek support: ☐ not required   ☐ needed (indicating denture flange)
— maxillomandibular relation (Angle class): ☐ Class I   ☐ Class II   ☐   Class   III   (to   be   compensated)
— interocclusal distance (ID): ☐ correct (~2–4 mm)   ☐ reduced   ☐ increased
— smile line: ☐ low   ☐ average   ☐ high
— upper lip length (distance subnasal to philtrum): ☐ long or average (>20 mm)   ☐ short (≤20 mm)
— upper incisal edge position: ☐ correct   ☐ too far cranial   ☐ too far caudal
— trigeminal nerve innervation ($V_{1,2,3}$ left/right): ☐ normal   ☐ paresthesia   ☐ anesthesia

(d) Intraoral aspects
Remaining dentiton
— general requirement: ☐ single tooth replacement   ☐ multiple tooth replacement
  ☐ full mouth reconstruction   ☐ edentulous jaw maxilla/mandible
— tooth prognosis: ☐ good _____   ☐ questionable _____   ☐ hopeless _____
— adjacent teeth: ☐ caries-free   ☐ well restored   ☐ require treatment
— malpositioned teeth: ☐ elongation _____   ☐ intrusion _____   ☐ ectopic position _____
— midline (upper centrals to philtrum): ☐ correct   ☐ too far left ___ mm   ☐ too far right ___ mm
— anterior tooth from: ☐ squared   ☐ tapered
— gingival course: ☐ low scalloped   ☐ high scalloped
— root orientation (Rx): ☐ diverging or parallel   ☐ converging
— functional exam: ☐ normal   ☐ abrasion and wear facetts

Edentulous space
— space width: ☐ ≥7 mm   ☐ < 7 mm
— alveolar ridge palpation: ☐ ideal contour   ☐ moderate ridge defects   ☐ advanced defects
— crown to bone relation/interarch space: ☐ optimal length of clinical crown   ☐ large discrepancy
  between incisor position and alveolar ridge (indicating augmentation or impRDP)
— mucosal quality: ☐ keratinized   ☐ non-keratinized, movable
— mucosal quantity: ☐ thick (molding possible)   ☐ thin, fragile

Existing RDP: ☐ sufficient   ☐ inadequate
  ☐ can be used as provisional   ☐ set-up and provisional restoration required

Fig 1. Checklist for patient's assessment.

supervision (Table 1). The chronological age *per se* is not a contraindication for implant placement but, particularly in older patients, the decision should depend on the treatment necessity and patient's ability to tolerate the procedure.

Table 1. Contraindications and increased risk for implant failures

	Disease	Assessment
Medical contraindications	• acute infectious diseases	– absolute, but temporarily; wait for recovery
	• chemotherapy	– absolute, but temporarily; reduced immune status
	• systemic bisphosphonate medication (≥2 yr)	– risk of bisphosphonate-induced osteonecrosis (BON)
	• renal osteodystrophia	– increased risk for infection, reduced bone density
	• severe psychosis	– absolute; risk of regarding the implant as foreign body and requesting removal despite of successful osseointegration
	• depression	– relative
	• pregnancy	– absolute, but temporarily; to avoid additional stress and radiation exposure
	• unfinished cranial growth with incomplete tooth eruption	– relative, but temporarily; to avoid any harm to the growth plates, to avoid inadequate implant position in relation to the residual dentition; utilize hand-wrist radiograph to evaluate end of skeletal growth single tooth implants in the anterior region not before 25th yr of age.[5]
Intra-oral contraindications	• pathologic findings at the oral soft- and/or hard tissues	– temporarily; increased risk for infection, wait until healing is completed
Increased risk for implant failure	• post head and neck radiation therapy	– reduced bone remodelling, risk of osteoradionecrosis, implant placement 6–8 weeks before or ≥1 yr after radiotherapy
	• osteoporosis	– reduced bone to implant contact;[6] consider calcium substitution, prolong healing period and avoid high torque levels for abutment screw fixation
	• uncontrolled diabetes	– eventually wound healing problems (impaired immunity, microvascular diseases)
	• status post chemotherapy, immuno-suppressants or steroid long-term medication, HIV infection	– eventually wound healing problems, medical advice required (consider corticosteroid cover)
	• alcohol and drug abuse, heavy smoking ≥20 cig/d	– eventually wound healing problems, locally reduced vascularization[7]
	• history of aggressive periodontitis	– increased risk to develop peri-implantitis

In young adults requiring single tooth replacement in the anterior region, implant placement should be postponed after the age of 25 due to the prolonged changes in anterior face height and posterior rotation of the mandible, particularly in women.[5]

Until the 1990s several general diseases were considered as strict contraindications, such as metabolic disorders (e.g., diabetes, hyperthyroidosis), cardiovascular diseases (e.g., hypertension, cardiac insufficiency, ischaemic heart disease), systemic bone diseases (e.g., osteomalacia, ostitis deformans, osteoporosis), or disorders of the haematopoietic system (e.g., anaemia, haemorrhagic diathesis). Today, these conditions indicate implant treatment under medical supervision and particular precautions should be considered, such as antibiotic prophylaxis, calcium-substitution, or substitution of coagulation factors.[8,9] Erosive disorders (e.g., epidermolysis bullosa, lichen planus) and hyposalivation with the symptoms of xerostomia (e.g., in patients with Sjögren-Syndrome or rheumatoid arthritis), are not a contraindication for implant treatment.[9] On the contrary, since patients with hyposalivation are at a higher risk of developing caries lesions due to the decreased salivary buffer capacity and reduced remineralization of enamel and dentine, implants may be favourable over teeth with questionable prognoses.

Different conditions and medications interfere with an uncomplicated wound healing and place the patient at higher risk for implant failure, e.g., alcoholism, smoking, a high American Society of Anesthesiology (ASA) score, periodontal disease and radiation therapy (Table 1).[10] Osteonecrosis of the jaw as observed in patients following radiation therapy of the head and/or neck has also been found in patients receiving intravenous bisphosphonates. This medication has been introduced as a treatment modality in patients with metastatic bone disease, in severe hypercalcaemia of malignancy, and for treating bone-resorption defects in multiple myeloma. Bisphosphonates are also used for the management of Paget's disease of the bone, severe osteoporosis and for the treatment of heterotopic ossification following total hip replacement and spinal trauma.[11] Under bisphosphonate therapy, bone resorption and normal bone turnover remodelling is inhibited by suppressing the recruitment and activity of osteoclasts. Patients taking intravenous drug medication for more than two years and those also using glucocorticoids, chemotherapeutics or receiving radiation of bone metastases in the jaw are particularly at risk of developing bisphosphonate-associated osteonecrosis (BON), while those taking low-dose oral bisphosphonates for a short period expose less risk. According to the Council of Scientific Affairs,[12] implant placement in patients taking bisphosphonates should be carefully considered, especially when extensive surgery with bone augmentation or regeneration is required. A clear contraindication for implant placement is given in those patients who have already experienced BON.

Patient's complaints and expectations

During the initial consultation, it is advisable to have the patient elicit his or her chief complaints, major concerns and treatment requests. These factors are associated with the expected improvements and can be evaluated using a written questionnaire in which patients place their mark on a visual analogue scale (VAS) at a point corresponding to their level of satisfaction or discontent with each criterion (Fig 1). The percentage given by the location of the cross (X) at the 10 cm horizontal beam is then related to the corresponding values between 0 and 100 using a gauge with scales from 0 to 100 mm.[13] In case of missing anterior teeth, aesthetic and psychosocial reasons may play a major role, while patients requesting tooth replacement in the posterior are most likely impaired by reduced function. Partially edentulous and edentulous patients might be asked, if they prefer fixed (FDP) or removable restorations (RDP), whether a palatal coverage with the prosthesis base is accepted and whether phonation problems or an excessive gag reflex exist (Fig 1).

Clinical examination

The clinical examination comprises several extra-and intra-oral aspects giving special attention to the alveolar bone and soft tissue contour and the possible implant reconstruction. A systematic approach is advisable and addresses the following extra-oral parameters (Fig 1):

(1) correct facial proportions (divided into 3 thirds: from hairline to eyebrow, to the subnasal point, to the chin);

(2) facial symmetry on front and in profile: parallelism among bipupilar line, smile line, occlusal plane and camper's plane;

(3) need for lip and cheek support: patients with removable prosthesis should be evaluated with and without the existing restoration in place so that a prosthesis flange for adequate support can be planned if deemed necessary;

(4) facial skeletal classification (normal, prognathic, retrognathic), need for compensation of a concave profile: check relation of the upper and lower lip to the aesthetic plane (line from the end of the nose to the chin) for "best balance of lips", which is given with equal distances or the lower lip slightly closer to this plane;

(5) intermaxillary relation: occlusal vertical dimension "OVD" (correct, reduced, increased); interocclusal distance "ID" in rest (correct with 2–4 mm, reduced, increased). In situations with a reduced occlusal vertical dimension, it is important to evaluate whether the interocclusal distance is increased and the OVD can be raised up to the desired dimension, or whether a muscular adaptation has occurred and ID decreased concurrently so that a staged rise of OVD is required;

(6) incisal edge position of the maxillary centrals and occlusal plane:[14] the incisal edge position of the centrals slightly surpassing the occlusal plane (about 1–2 mm below) is a key point for evaluating the adequate position of the occlusal plane and the bite relation. The position of the centrals is evaluated in rest and related to the upper lip length, as well as during smiling in relation to the height of the smile line. The upper lip length is measured from the base of the column (subnasal) to the philtrum in rest and determines the amount of the incisal edges of the maxillary centrals visible during rest. With short lip length (10–15 mm) about 4 mm are visible, average length (21–25 mm) expose approximately 2 mm, and in long upper lip length (31–35 mm) the incisors are barely visible (0.25 mm). Patients with a high smile line generally expose the entire clinical crown with surrounding gum tissues, while with an average smile line, the central incisors are mainly visible, and with a low smile line less than 75 per cent of the incisors' length is exposed. When the alveolar ridge is displayed in patients with a high smile line, special consideration has to be given to the aesthetic aspects and the predictability of the outcome of a possible implant treatment;

(7) neurologic test of areas innervated by the trigeminal nerve to ascertain any sensitivity anomalies to serve as a baseline assessment in case of intra-operative nerve lesions;

(8) temporomandibular joint movement and function, contraction or hypertrophy of the facial musculature as an indicator of parafunctional habits (together with abrasion and wear facets on the occlusal surfaces).

Intra-oral examination

The intra-oral examination comprises:

(1) dental examination including existing restorations and reconstructions, decayed and filled teeth, oral hygiene assessment, periodontal exam and dental pulp test; detection of malpositioned teeth (elongation, intrusion, ectopic tooth position); midline between upper central incisors corresponding to the philtrum position;

(2) edentulous regions: ridge defects (vertical, horizontal, combined), crown to bone relationship (distance between the ideal position of the clinical crowns and the underlying bone), defect compensation with soft and/or hard tissue feasible or prosthesis basis required;

(3) quality/quantity of the mucosa and contour of the underlying bone: any pathologies and pressure spots are recorded and the magnitude of the alveolar ridge resorption is examined. The mucosal quality and quantity with the underlying bone can be assessed by palpation and/or sounding. A thick keratinized mucosa is easier to mould for a papillary-like inter-implant trigonum than a thin, flappy, non-keratinized ridge

tissue. Sufficient mucosal thickness helps to hide the abutment margin and better facilitates correct emergence profile of the clinical crown;

(4) existing prosthesis: prosthesis basis, inter-/intramaxillary relation, size/form/position/colour of denture teeth. Depending on further planning, a decision is made whether the existing restoration is sufficient and tooth arrangement is applicable to the new restoration, whether this restoration can serve as provisional, or whether an additional diagnostic set-up and an interim prosthesis is required;

(5) occlusal status and functional exam: the diagnosis of parafunctional habits (bruxism, clenching) can be deduced from clinical findings of muscular tension and hypertrophy, dental abrasion, attrition and wear facets. Although parafunction itself is not a contraindication for implant placement it can, if uncontrolled, cause technical complications such as screw or framework fractures due to overloading. Therefore, initial therapy of temporomandibular disorders is indicated presurgically to reduce the eventual occlusal stresses and provide better chances of long-term success.[15]

Aspects for treatment planning

For the three different starting points, specific aspects for implant treatment planning have to be considered during extra-and intra-oral examination:

(1) Single tooth replacement: the decisive aspects whether a single tooth implant is indicated or a fixed dental prosthesis is preferable are related to the condition of the adjacent teeth and the neighbouring anatomic structures. Decayed or filled adjacent teeth and those in need of recontouring in form and/or colour, insufficient mesiodistal space and unpredictable outcome of the soft tissue contour in the aesthetic zone are clear indications for a conventional fixed dental prosthesis. On the other hand, sound tooth structure of adjacent teeth, converging root alignment, sufficient bone quantity and thick soft tissue quality are good predictors for a successful implant therapy.

(2) Partially edentulous case: a major indication for implant placement is the free-end situation when removable appliances should be avoided. Another important indication is given in the reduced dentition, when the risk of long-span fixed dental prostheses should be minimized, especially when abutment prognosis is compromised. Abutment teeth may be classified as questionable due to advanced attachment loss in periodontal cases, persisting apical lesions in endodontically treated teeth or prosthetic impairment with reduced tooth structure and insufficient ferrule. While maintaining a questionable tooth in a given situation may be reasonable, including this tooth as decisive abutment in an fixed dental prosthesis would increase the risk for failure of the entire reconstruc-

tion. Within the frame of a comprehensive treatment planning, extraction of such questionable teeth may be preferable in order not to interfere with the long-term prognosis of the reconstruction and/or to facilitate strategic implant placement and reasonable planning of the superstructure. In some situations, this "restoration-related" decision to extract a questionable tooth enables short-span fixed dental prostheses at lower risk, preferably implant-borne fixed dental prostheses rather than combined implant-tooth-supported fixed dental prostheses.

In the partially edentulous case planned for a removable appliance, additional retention can be derived from implant abutments. Implants used as additional retainers of a removable denture prosthesis facilitate an increase in prosthesis stability and retention, and aid in enhancing the patient's comfort when the extension of the prosthesis bases can be reduced.

(3) Edentulous case: especially in restoring the edentulous jaw, it is important to evaluate and specify the patient's desires and expectations related to implant therapy, which may vary greatly. In the edentulous mandible, for instance, a majority of patients suffer from poor retention of their existing complete denture and just expect a better prosthesis stabilization, which can be derived from two interforaminal implants and a combined implant-retained and soft tissue-supported overdenture prosthesis. Others suffer from recurrent sore and pressure spots on frail soft tissues and benefit from solely implant-supported prostheses (removable or fixed).[16] Especially in the edentulous maxilla, some patients refuse to consider complete denture status when transitioning from partially edentulous state to edentulism.[15] Fixed restorations are also preferred, when an increase in comfort similar to those given with the natural dentition is desired. Facial support plays an important role in patients with advanced alveolar bone resorption resulting in a retrognathic appearance of the maxilla. The need for compensation of a concave profile or prognathism with a prosthesis flange is decisive for a removable prosthesis rather than a fixed restoration.[14] With difficulties in personal oral hygiene, expected speech problems in the maxilla or food entrapment in the mandible with a high floor of the mouth, a removable denture prosthesis is preferable and offers more flexibility in the tooth arrangement and prosthesis design.

Diagnostic aids

In addition to the diagnosis and definition of any treatment needs, the prognosis of every single tooth of the residual dentition is classified as good, questionable and hopeless. Based on these aspects a treatment plan is made that includes the different treatment options with any pretreatment necessities. In complex cases

requiring several extractions of hopeless teeth and provisionalization of the remaining dentition, a re-examination is generally needed following periodontal, operative and/or surgical pretreatment in order to evaluate the response to the first phase of treatment. This initial phase is required for resolution of periodontal inflammation and caries lesions, for endodontic treatment, to facilitate proper interproximal cleaning, and to establish an adequate inter-and intramaxillary relation and occlusal scheme. In addition, the provisional fixed or removable prosthesis helps to determine the appropriate tooth contour and position as to fulfil the aesthetic and phonetic requirements. During this re-examination the prognosis of any questionable tooth has to be revisited and adequate implant number and position determined.[17]

Radiologic diagnosis

Pre-operative radiographs are required not only to evaluate the existing bone quantity but also to identify neighbouring anatomic and topographic structures which have to be preserved (Fig 2).[18] Important anatomic structures are the roots of the adjacent teeth, the course of the inferior alveolar nerve, the floor of the nose, the diameter of the incisal canal, and the morphology of the maxillary sinus including bony septi. Panoramic radiographs provide a good two-dimensional overview, facilitate detection of pathologies in the jaw bone and assessment of bone quantity in the vertical and the mesiodistal dimension. Panoramics are therefore considered as standard radiographic examination for the initial diagnosis and implant treatment planning.[18] For single tooth spaces, additional periapical radiographs made with a parallel-cone technique facilitate an adequate evaluation of the orientation of the neighbouring roots in most instances. In the partially edentulous, periapical radiographs of the entire dentition are recommended to facilitate a comprehensive treatment planning. For diagnosing the edentulous patient, the panoramic radiograph with a magnification factor of mostly 1:1.3 enables planning of the implant length and position in uncomplicated situations such as two interforaminal implants in the mandible. But also in this presumably simple situation, a three-dimensional orientation can be difficult to ascertain due to morphologic changes occurring during long-term edentulism and leading to varying degrees of resorption (Fig 3).

Whether or not additional cross-sectional imaging techniques are required depends on the complexity of the anatomic situation and/or planned augmentation procedures, as well as the difficulty of the intended restoration and the practitioner's experience.[18,19] The tomography produces a third dimension in a second plane, i.e., the parasagittal plane, and facilitates the

Anterior maxilla:

– canine fossa

– nasal floor

– nasopalatine nerve

Posterior maxilla:

– maxillary sinus

■ : quantity and quality mainly good

■ : quantity frequently insufficient, quality mainly good

■ : quantity and quality mainly problematic

Anterior mandible:

– mental fossa

– minor vessels, muscles

Premolar region:

– sublingual, submental artery with mental rami

– inferior alveolar nerve

Molar region:

– facial, ascending pharyngeal artery with tonsil rami

– lingual, mylohyoid, inferior alveolar nerve

Fig 2. Assessment of bone quality and quantity, anatomic and topographic structures.
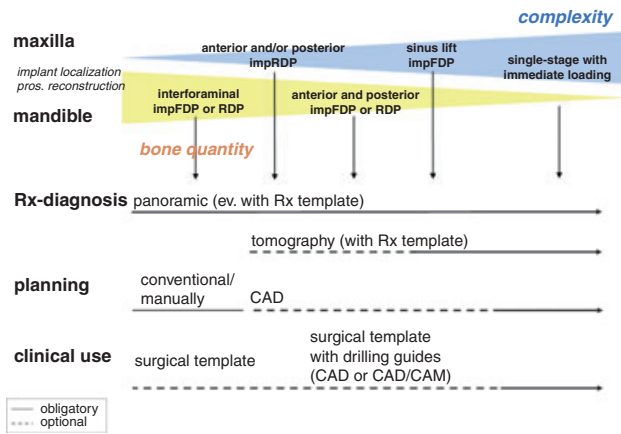
Fig 3. Implant diagnostics in the edentulous jaw.

evaluation of the bone quantity in the bucco-oral dimension, better orientation for the identification of anatomic structures and/or optimal implant positioning. Depending on the size of the edentulous segment and the intended clinical procedure, conventional tomographies or computer-assisted tomographies (spiral-computer tomography or digital volume-tomography) are used. With the latter, data are reformatted into secondary reconstructions and transferred to the dentist for implant planning as a digital file and/or printed on paper or radiographic negative (Fig 3).

When fixed restorations and single-stage surgery with immediate loading are intended, the computer-assisted implant planning facilitates the pre-operative production of biomodels with surgical templates. These templates allow exact drilling and immediate insertion of a prefabricated provisional restoration.[20]

Study casts

The clinical situation is normally analysed with the aid of study models. If removable appliances are present, situation casts can be made with and without the prostheses in place and mounted when used for further diagnostics. Anticipated changes in tooth position or correction of the midline are transferred to these study casts to inform the laboratory technician about the planned changes, which should be already accomplished in the diagnostic set-up. This set-up can be used for additional radiographic analysis (Rx template; Fig 3), modified as surgical template and also incorporated into the provisional restoration. The amount of bone resorption in the horizontal and vertical dimensions can be estimated by the ideal placement of the proposed teeth in the set-up in relation to the presenting anatomical situation ("crown to bone relationship").[14] If the ideal clinical crown ends up at the soft tissue level of the alveolar ridge, then only minimal bone resorption is present. When a large vertical distance results between the ideal positioned artificial teeth and the underlying tissues, moderate to severe resorption of the edentulous ridge area may have occurred and defect compensation by bone augmentation procedures or with a prosthesis flange has to be considered.

CONCLUSIONS

Although only few absolute contraindications to implant treatment exist, there are numerous protocols, recommendations and educational material to properly inform the patient about implant treatment, the associated risks and possible complications. These attempts in patient information are far beyond those endeavours made over decades for conventional reconstructive therapies, and are at least in part, a result of the increasing number of medico-legal problems. The current review clearly revealed the necessity of a thorough, structured procedure for patient assessment. Consequently, this assessment has to end up in a recommendation for implant therapy or, otherwise, conventional treatment alternatives are preferable. Despite all the benefits associated with implant therapy, a more predictable outcome seems to be associated with the conventional therapies, at least in some complex situations when aesthetics are paramount. This understanding implies the need for a discriminating patient assessment and a comprehensive treatment plan that includes the different treatment options with any pretreatment necessities. The practitioner's role, giving an honest treatment recommendation based on his/her specialization and experience, is of upmost importance. Advantages and disadvantages of the recommended therapy and treatment alternatives, including non-replacement, are explained to the patient. Costs, efforts, expected outcome, possible risks and complications, long-term results and maintenance efforts including their own responsibility in treatment are described and the final treatment decision is taken with consent of the informed patient.

REFERENCES

1. Chee W, Jivraj S. Failures in implant dentistry. Br Dent J 2007;202:123–129.
2. Santoro V, De Donno A, Dell'Erba A, Introna F. Esthetics and implantology: medico-legal aspects. Minerva Stomatol 2007;56:45–51.
3. Hardt CR, Gröndahl K, Lekholm U, Wennström JL. Outcome of implant therapy in relation to experienced loss of periodontal bone support: a retrospective 5-year study. Clin Oral Implants Res 2002;13:488–494.
4. Hämmerle CH, Jung RE, Feloutzis A. A systematic review of the survival of implants in bone sites augmented with barrier membranes (guided bone regeneration) in partially edentulous patients. J Clin Periodontol 2002;29(Suppl 3):226–231. Discussion 232–233.
5. Jemt T, Ahlberg G, Henriksson K, Bondevik O. Tooth movements adjacent to single-implant restorations after more than 15 years of follow-up. Int J Prosthodont 2007;20:626–632.

6. Fini M, Giavaresi G, Rimondini L, Giardino R. Titanium alloy osseointegration in cancellous and cortical bone of ovariectomized animals: histomorphometric and bone hardness measurements. Int J Oral Maxillofac Implants 2002;17:28–37.

7. Strietzel FP, Reichart PA, Kale A, Kulkarni M, Wegner B, Küchler I. Smoking interferes with the prognosis of dental implant treatment: a systemic review and meta-analysis. J Clin Periodontol 2007;34:523–544.

8. Marder MZ. Medical conditions affecting the success of dental implants. Compend Contin Educ Dent 2004;25:739–742.

9. Scully C, Hobkirk J, Dios PD. Dental endosseous implants in the medically compromised patient. J Oral Rehabil 2007;34:590–599.

10. Parameter on placement and management of the dental implant. American Academy of Periodontology. J Periodontol 2000; 71(Suppl 5):870–872.

11. Diel IJ, Body JJ, Lichinitser MR, *et al*. Improved quality of life for long-term treatment with the bisphosphonate ibandronate in patients with metastatic bone disease due to breast cancer. Eur J Cancer 2004;40:1704–1712.

12. Report of the Council on Scientific Affairs. Dental management of patients receiving oral bisphosphonates therapy–expert panel recommendations. American Dental Association. June 2006.

13. Zitzmann NU, Sendi P, Marinello CP. An economic evaluation of implant treatment in edentulous patients-preliminary results. Int J Prosthodont 2005;18:20–27.

14. Zitzmann NU, Marinello CP. Treatment plan for restoring the edentulous maxilla with implant-supported restorations: removable overdenture versus fixed partial denture design. J Prosthet Dent 1999;82:188–196.

15. Henry PJ. A review of guidelines for implant rehabilitation of the edentulous maxilla. J Prosthet Dent 2002;87:281–288.

16. Zitzmann NU, Marinello CP. Decision-making and treatment planning in the edentulous mandible restored with fixed or removable implant prostheses. URL: http://www.worlddent.com. Accessed October 2004.

17. Bader HI. Treatment planning for implants versus root canal therapy: a contemporary dilemma. Implant Dent 2002;11:217–223.

18. Dula K, Mini R, van der Stelt PF, Buser D. The radiographic assessment of implant patients: decision-making criteria. Int J Oral Maxillofac Implants 2001;16:80–89.

19. BouSerhal C, Jacobs R, Quirynen M, van Steenberghe D. Imaging technique selection for the preoperative planning of oral implants: a review of the literature. Clin Implant Dent Relat Res 2002;4:156–172.

20. van Steenberghe D, Naert I, Andersson M, Brajnovic I, van Cleynenbreugel J, Suetens P. A custom template and definitive prosthesis allowing immediate implant loading in the maxilla: a clinical report. Int J Oral Maxillofac Implants 2002;17:663–670.

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