The Foundation of Knowledge

4th IF® Consensus Document on Standard Algorithms for Osseointegrating and Osseofixated Implants

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1. Introduction

Osseointegration is defined as the direct contact between living bone and dental implant surface without interposed soft tissue at the light microscope level [1, 2]. The nature of the bony contact zone depends on the type of bone that is in contact with the bone's surface. If osteonal bone is in direct contact with the implant surface, the outer layer of the osteons which show low / no mineralization are in contact with the bone. This was earlier misunderstood as „fibrointegration".

Osseofixation is described as the anchorage of the implant by the surgeon on the cortical bone. This can be achieved through macro-mechanical anchorage on the first, second or third cortical, often followed by secondary osseointegration (or osseoadaptation) of those parts of the implant that are not in contact with a cortical or the bone at all [3, 4]. This event depends on the functional stimulus on bone.

There are key differences between the algorithms for osseointegrating and osseofixated implants. These differences should be highlighted for educational purpose to the treatment providers. Additionally, these differences should be considered during treatment planning, implant (anchoring) principles, surgical and prosthetic techniques, the overall probability of success, and follow-up measures. Note that the combination of implants for osseointegration and for osseofixation has never been scientifically proven.

The differences in algorithms include the following aspects:

1. The implantation principle
2. The patient selection
3. The surgical technique
4. The prosthetic approach
5. The follow-up and maintenance program
6. Implant failure modes

2. Differences Between the Algorithms for Osseointegrated and Osseofixated Implants

2.1 The Implantation Principle

Osseointegrating Implants

- **Principle**: Osseointegrated implants rely on an ankylotic connection of the endosseous implant surface with the cancellous bone. Osseointegration is the process by which the implant reaches direct contact with the bone, a contact that was not given right after placement of the implant. Osseointegration involves new bone formation and the growth of the bone towards the implant [1, 2, 5, 6]. This process needs time, which is referred to as a „healing period“. However, this process was never scientifically proven in detail
- **Imaging**: Detailed 3D imaging (CBCT) is often used prior to implantation to accurately evaluate the quality and quantity of the bone, to plan the correct position of the implants, and to avoid neighboring vital anatomical structures. This is of great significance, especially in elderly patients, because the implants are often too large for the jawbone area in which they have to be placed from a static point of view [7, 8]

Osseofixated Implants

- **Principle**: These implants anchor primarily in the second and third cortical of the jawbones through macro-mechanical anchorage, which provides high stability [8-10]. The implants can also pass through soft tissue (mucosa or muscle attachments in the area of the second or third cortex) or in / through cavities (enucleated cysts, maxillary sinus, nasal cavity). Third cortical anchorage refers to the anchorage in the cortical of the pterygoid process of the sphenoid bone
- **Imaging**: Panoramic X-rays are primarily used; however, CT scans or cone beam CT may be used postoperatively to verify the good anchorage of the implant in the second or third cortical. In cases of severe atrophy, CT scans or cone-beam CT may be used pre- and post-operatively. The pre-operative use of cone beam CT is to verify the possibilities of reaching the second cortical with the load transmitting implant parts and the drills. The quality of the second cortical is of less significance to be investigated. Hence, the functional loading of the bone will enhance mineralization in the shortest time. Always remember, „There is no possibility to improve the quality of the bone, except, by using it more and more for load transmission“. For weak (cortical) bone situations, the surgeon’s decision should be to place more implants in the affected jawbone or jaw segment, and not to try bone augmentation

2.2 The Patient Selection

Osseointegrating Implants

Patient selection is done very strictly and with various criteria for general health, bone quality, and quantity. Patients with insufficient bone usually require bone reconstruction procedures, a procedure that is always associated with additional risks [11-13]. The medical condition of the patient, the oral hygiene, the patient's smoking habits, and the surgical experience of the treatment provider may limit this treatment option in many patients [15-18].

Moreover, due to strict criteria for the minimal state of patient's health, this leads to frequent rejection of elderly patients, the group of patients who require implants most [18]. From this point of view, osseointegrating (ankylosing) implants are mainly used in the age group between 25 and 60 years.

Osseofixated Implants

Osseofixated implants utilize the basal bone for anchorage; hence, almost all the patients have sufficient jawbone for this straightforward and modern method of implantology. Bone augmentation is never part of the treatment plan if this method is used. The complete avoidance of any kind of bone manipulation increases the number of potential patients compared to all other methods of implantology.

Moreover, a high survival rate was reported in cases with a history of periodontitis and smoking [19]. Nevertheless, treatment with intravenous bisphosphonates represents an incalculable risk for any bone surgery and logically, this also poses an increased risk with these implants [9, 10].

2.3 The Surgical Technique

Osseointegrating Implants

- **Implant placement**: Osseointegrating implants are inserted into the cancellous bone after an implant osteotomy. This implant osteotomy (implant drilling) results in damaged osteonal systems along the osteotomy. In order to achieve primary stability the implant osteotomy is held smaller than the actual circumference of the implant. By inserting the implant, it is pressed into the prepared bone cavity. This creates a primary bone-to-implant contact. Conical implants tend to achieve higher primary stability compared to cylindrical implants. According to the theory of „osseointegration" this contact zone undergoes some remodeling over time, resulting in new bone formation referred to as a secondary bone contact [5]. Thus, the stability of the implant relies mainly on the osseointegration process that takes place over time. Therefore, a healing period is necessary before the implant can be loaded. This dynamic process of bone remodeling directly impacts the primary stability of the implant. Thus, the stability of the implant may decrease during the first three to four weeks of „healing“ [6]. Any disturbance in this healing process can result in early implant failure. Literature related the cause of early implant failure (i.e.: before prosthesis insertion) to fibrous tissue formation between the implant and the surrounding bone in the early healing period [20]. Despite the lack of a definitive definition for the primary predisposing factor leading to early implant failure, several factors may contribute, such as bone quality and quantity, the patient‘s medical condition, smoking habit, the implant site and technique, the inserted implant size (diameter and length), the inserted torque, the surgical technique and skill, and their combination with the grafting procedure [20–25]. Bone augmentation procedures are commonly used to add bone-like tissues to the available amount of (atrophied) natural bone. By applying such an „augmentation“, the skeleton of the patient is surgically modified to fit the osseointegrating implant [24, 25]. Bone augmentations add costs and medical risks to the procedure. Additionally, they prolong the treatment due to the additionally required healing time for the „graft“ [26]. Many investigations [27-29] have highlighted the association between early implant failure and bone grafting

- **Treatment steps**: While the placement of osseointegrating implants is a single-step procedure, additional surgical steps are necessary for these implants because their demand for bone is large. Only a few patients provide enough natural bone to host osseointegrating implants without bone augmentation

Osseofixated Implants

- **Implant placement**: Osseofixated implants may be placed into fresh extraction sockets or into healed bone sites long after the extraction. They are actively anchored by the surgeon directly in the second or third cortical. This creates immediate high stability [9, 10, 30, 31]. While implants for osseointegration pass through the mucosa on the oral side of the alveolar crest, osseofixated implants penetrate also through the other side of the jaw bone (the second cortical) and often (depending on the anatomy of the site) also through or at least into the soft tissues on the other side of the second or third cortical. In some anatomic sites, the implants are reaching muscle attachment areas, which provides an exceptional strong protection against loss of mineralization due to the muscle forces [31]

- **Treatment steps**: Immediate functional loading is the first method of choice. The prosthesis is connected rigidly connected to the implant within a period of 72 hours, i.e. before osteonal remodeling can set in. The prosthesis serves not only as masticatory device, but also as a (necessary) splint to stabilize the implants

2.4 The Prosthetic Treatment

Osseointegrating Implants

- **Loading protocol**: For the majority of the cases conventional delayed loading was emphasized; hence, the implant is only loaded after osseointegration is ensured, i.e., after several months. Immediate functional loading can be used in specific cases. The literature reported an increased incidence of implant failure with an immediate loading protocol in osseointegrating implants compared to delayed load [32-35] and highlighted the role of smoking, implant length [32], implant site [33], and bone grafting
- **Design of the prosthesis**: It can be either fixed or removable; however, in the case of a denture-supported prosthesis, the final prosthesis is fitted after the healing phase

Osseofixated Implants

- **Loading protocol**: Due to stable anchorage in the second or third cortical bone layers, implants can be loaded immediately with high, predictable success and excellent biomechanical force distribution
- **Design of the prosthesis**: Fixed prostheses are used even in severely resorbed cases, with significant improvement in the patient's oral health and functions, as well as high reported patient satisfaction and improved quality of life [19, 30, 36]
- **Dentures**: The dentures are attached within 72 hours after implant placement and they serve to stabilize the implants

Zirconium has been intensely used as a bridge material both on osseointegrating and osseofixated implants with high success [37, 38].

2.5 The Follow-Up and Maintenance Program

Osseointegrating Implants

- **Follow-up**: Require regular check-ups to monitor the osseointegration and adjust the prostheses. The full healing process (i.e. the time period for adaptation and consolidation) takes up to two years. This means that after "osseointegration" is reached and the implant is loaded, more adaptation of the bone and changes in its morphology must be expected. Some of these changes are denominated as "periimplantitis". Although we know today that the onset of periimplantitis is a bone driven development and not mainly the result of an infection [39, 40] regular oral hygiene is assumed necessary to avoid progression of periimplantitis. It is assumed that medical and local factors, smoking, and old age could be co-factors for the development of a periimplantitis [14-18]

Osseofixated Implants

- **Follow-up**: Depending on the type of prosthetic construction and other circumstances of the treatment, the first control appointment will take place one to three months after the initial treatment, and then every nine to twelve months. After two to four years, most patients can be referred to longer check-up intervals. The aftercare protocol includes adjusting the chewing surfaces, increasing the height of the bite and the sagittal bite position, checking the implant stability, and restoring the free mobility of the bridge against the mucosa on the jawbone. Correcting early contacts and incorrect loading allows for the regression of any cortical overload osteolysis, provided that this intervention occurs in a timely manner [41]

The discussed differences in algorithm reflect the diverse principles of anchoring and treatment between osseointegrating and osseofixated implants and their understanding plays a significant for providing successful treatment results and assessing later the necessity of carrying out correct treatment planning, a successful surgical and prosthetic phase, the maintenance and the aftercare protocol in general (including corrective interventions).

2.6 Implant Failure Modes

Osseointegrating Implants

Literature has reported an association between the 2-stage rough implants and the incidence of periimplant mucositis or periimplantitis [42, 43]. In a recent systematic review including 57 studies, Dreyer et al. [42] reported an incidence range of 1.1% to 85.0% of periimplantitis at implant level, with a prevalence of 0.4% within three years to 43.9% within five years. Another study by Derks et al. [43] showed that periimplantitis started early and that at years two and three, 52% and 66% of implants had bone loss of >0.5 mm, respectively. This complication could potentially impact the overall success of the implant and treatment, as it puts the entire implant at risk until it undergoes removal or exfoliation.

A consequence that significantly reduces the patient satisfaction and quality of life.

Furthermore, reports have documented a number of mechanical failures, including crown fractures, framework fractures, screw loosening, screw fractures, and fixture fractures [44]. Hence, some implantologists may prefer the use of screw-type prostheses to ensure the possibility of unscrewing the prostheses to replace the broken part and / or failing to remove implants if mechanical complications occur.

Osseofixated Implants

Osseofixated implants never develop periimplantitis due to the smooth surface of the implant [3, 9, 14], the only exception is if the treatment provider or the patient roughens the polished implant surfaces.

On the other hand, osseofixated implants show the risk of mechanical overloading, especially during the first 24 months. Hence, to avoid this complication, regular clinical follow-up visits are mandatory to examine and adjust the patient's occlusion. The most important follow-up appointment is the three months' control [3, 9, 41].

Moreover, these implants or the whole Bone-Implant-Prosthetic-System (BIPS) can fail if the stabilizing rigid splint of the BIPS has been completely or partially lost (prosthetic loosening of crowns; fractures of the bridge) or due to the use of temporary cement to fixate the prosthesis [45].

3. Highlights on the Osseofixated Implants

A number of studies have shown that osseofixated implants provide a significant improvement in oral health compared to cases treated with the conventional osseointegrating implants. Many investigators documented a high survival and success rates, with a greater advantage of lack of periimplantitis with osseofixated implants [46–65].

Therefore, when planning to use conventional (osseointegrating) implants, it is crucial to ensure accurate patient information, particularly for patients with compromised ridge support that would require additional bone augmentation. For this reason, today updated requirements are valid. This includes information about the fact that in oral implantology bone augmentation is not necessary any more, and that the standard treatment protocol for osseofixated implants includes an immediate functional loading protocol.

The method of osseofixation also presents a breakthrough in the management of maxillofacial defects where these implants yield high long-term survival rates, significant improvement in aesthetics and function, the patient's self-esteem, patient satisfaction, and the quality of life [60–65].

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The Foundation of Knowledge

Index for Changes in Rev. 3 of the IF® Consensus Document No. 4

Revision No.	Document name / number	New version	Previous version	Modification	Date of approval	Release by
2	4_EN_Consensus_on_standard_algorithms_for_osseointegrating_and_osseofixated_implants_2024-04_V003	3 (2024)	2 (2022)	-	11.04.2024	IF® Board
1	EN_Consensus_for_implantology_to_achieve_osseointegration_04-22_V002	2 (2022)	1 (2012)	-	29.04.2022	IF® Board
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