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Transcutaneous Osseointegrated Prosthesis Systems (TOPS) for Rehabilitation After Lower Limb Loss

Surgical Pearls

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Abstract

Background: The biology of osseointegration of any intramedullary implant depends on the design, the press-fit anchoring, and the loading history of the endoprosthesis. In particular, the material and surface of the endoprosthetic stem are designed to stimulate on- and in-growth of bone as the prerequisite for stable and long-lasting integration[1-8]. Relative movement between a metal stem and the bone wall may stimulate the formation of a connective-tissue interface, thereby increasing the risk of peri-implant infections and implant loss[9-12]. The maximum achievable press-fit (i.e., the force closure between the implant and bone wall) depends on the diameter and length of the residual bone and thus on the amputation level. Beyond this, the skin-penetrating connector creates specific medical and biological challenges, especially the risk of ascending intramedullary infections. On the one hand, bacterial colonization of the skin-penetrating area (i.e., the stoma) with a gram-positive taxon is obligatory and almost impossible to avoid[9,10]. On the other hand, a direct structural and functional connection between the osseous tissue and the implant, without intervening connective tissue, has been shown to be a key for infection-free osseointegration[11,12].

Description: We present a 2-step implantation process for the standard Endo-Fix Stem (ESKA Orthopaedic Handels) into the residual femur and describe the osseointegration of the prosthesis[13]. In addition, we demonstrate the single-step implantation of a custom-made short femoral implant and a custom-made humeral BADAL X implant (OTN Implants) in a patient who experienced a high-voltage injury with the loss of both arms and the left thigh. Apart from the standard preparation procedures (e.g., marking the lines for skin incisions, preparation of the

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distal part of the residual bone), special attention must be paid when performing the operative steps that are crucial for successful osseointegration and utilization of the prosthesis. These include shortening of the residual bone to the desired length, preparation of the intramedullary cavity for hosting of the prosthetic stem, precise trimming of the soft tissue, and wound closure. Finally, we discuss the similarities and differences between the Endo-Fix Stem and the BADAL X implant in terms of their properties, intramedullary positioning, and the mechanisms leading to successful osseointegration.

Alternatives: Socket prostheses for transfemoral or transtibial amputees have been the gold standard for decades. However, such patients face many challenges to recover autonomous mobility, and an estimated 30% of all amputees report unsatisfactory rehabilitation and 10% cannot use a socket prosthesis at all.

Rationale: Transcutaneous osseointegrated prosthetic systems especially benefit patients who are unable to tolerate socket suspension systems, such as those with short residual limbs and/or bilateral limb loss. The use of a firmly integrated endoprosthetic stem allows patients and surgeons to avoid many of the limitations associated with conventional socket prostheses, such as the need to continually fit and refit the socket to match an ever-changing stump[6,14-19]. Discussion between patients who are considering an osseointegrated prosthesis and those who have already received one ("peer patients") has proven to be a powerful tool to prevent unrealistic expectations. Patients with a transhumeral amputation especially benefit from the stable connection between the residual limb and exoprosthesis. Motion of the affected and even the contralateral shoulder is no longer impaired, as straps and belts are dispensable. Furthermore, transmission of myoelectric signals from surrounding muscles to the prosthesis is fundamentally improved. However, comorbidities such as diabetes mellitus or peripheral arterial disease require careful counseling, even if these conditions were not responsible for the loss of the limb. Transcutaneous osseointegrated prosthetic systems for replacement of an upper or lower limb might not be an option in patients who are unable, for any reason, to take adequate care of the stoma.

Expected Outcomes: Despite subtle differences between the systems utilized for the intramedullary anchoring of the prosthetic stem, all data indicate that mobility and quality of life significantly increase while the frequency of stoma infections is remarkably low as long as the patient is able to follow simple postoperative care protocols[2-5,9,10,13-19].

Important Tips: The impaction pressure of the implant depends on the diameter of the implant and the quality of the residual bone (i.e., the time interval between the amputation and the implantation of the prosthetic stem). The extent of reaming of the inner cortex of the residual bone must be adapted to these conditions. The standard Endo-Fix Stem and BADAL X implant are both slightly curved to adapt to the physiological shape of the femur. Thus, the surgeon must be sure to insert the implant in the right position and at the correct rotational alignment. When preparing a short femoral stump, carefully identify the exact transection level in order to obtain enough bone stock to anchor the implant in the correct intramedullary position for an additional locking screw into the femoral neck and head. Depending on the residual length of the humerus and the press-fit stability of the implant, the utilization of locking screws is optional, as a notch at the distal end of the implant guarantees primary rotational stability.

Acronyms and Abbreviations:

- TOPS = transcutaneous osseointegrated prosthesis systems
- EEP = endo-exo prosthesis
- MRSA = methicillin-resistant *staphylococcus aureus*
- a.p. = anteroposterior
- K-wire = Kirschner wire
- CT = computed tomography
- DCA = double conus adapter
- OFP = osseointegrated femur prosthesis

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