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Second-stage implant surgery: Clinical techniques, biological considerations and emerging concepts - A review

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Abstract:
Second-stage implant surgery involves uncovering osseointegrated implants and placing healing abutments to establish optimal peri-implant soft tissue healing. Therefore, it is of interest to evaluate the surgical techniques, including flap elevation, tissue punch, laser-assisted exposure and soft tissue augmentation. Flap techniques improve surgical visibility, whereas minimally invasive approaches may reduce postoperative discomfort and tissue trauma. The one-abutment-one-time protocol and advances in minimally invasive techniques enhances tissue stability and clinical outcomes. Thus, data shows the biological principles, surgical approaches, clinical outcomes and recent innovations in second-stage implant surgery.

Keywords: Second-stage implant surgery, implant uncovering, healing abutment, peri-implant tissue, surgical technique, minimally invasive methods dental implants

Background:
Two-stage dental implant therapy involves submerged implant healing followed by a second surgical procedure to establish transmucosal access for prosthetic rehabilitation **[1]**. During the first stage, the implant is positioned within the alveolar bone and covered with a healing screw or cover screw to allow osseointegration **[2].** The second stage exposes the implant and permits placement of a healing abutment to condition the peri-implant soft tissues before definitive restoration **[3].** The characteristics of the peri-implant mucosa established during this stage can influence keratinized tissue dimensions, soft-tissue stability and long-term peri-implant health **[4]**. Adequate keratinized mucosa has been associated with improved plaque control and reduced peri-implant inflammatory changes, although its relationship with marginal bone stability remains variable **[5]**. Surgical manipulation during implant exposure can also influence soft-tissue architecture, mucosal recession and the emergence profile of the definitive restoration **[6].** Contemporary second-stage approaches therefore increasingly emphasize minimally invasive soft-tissue management and preservation of the peri-implant mucosal architecture **[7]**. Therefore, it is of interest to evaluate the clinical and soft-tissue outcomes associated with different second-stage implant exposure techniques and to evaluate their influence on peri-implant tissue health and esthetic parameters.

Biological basis of second-stage surgery:
The biological width around dental implants, analogous to that around natural teeth, requires an adequate zone of keratinized attached gingiva (KAG) to resist functional and inflammatory challenges **[8]**. Unlike the junctional epithelium around natural teeth, the peri-implant epithelium lacks inserting connective tissue fibers into the implant surface, making it inherently more vulnerable to pathogenic infiltration **[9]**. A minimum of 2 mm of keratinized gingiva on each side of the implant has been advocated as a clinical threshold below which peri-implant health becomes compromised **[12, 22]**. When keratinized tissue is insufficient, peri-implantitis - a destructive inflammatory condition affecting the peri-implant soft and hard tissues - can develop rapidly, leading to progressive alveolar bone loss and potential implant failure **[10].** The critical clinical principle governing Stage II technique selection is therefore the pre-existing width of KAG at the implant site. When adequate KAG is present (≥4 mm), minimally invasive techniques such as tissue punch uncovering may be employed without significant tissue sacrifice. When KAG is borderline (2–4 mm) or deficient (<2 mm), flap-based and augmentative procedures are indicated to preserve or enhance the tissue width around the emerging implant **[11].**

Timing of second-stage surgery:
The timing of second-stage surgery is governed by the quality of the surrounding bone and the degree of implant stability achieved during the healing phase. In the mandible, where bone density is generally greater, the recommended healing period prior to implant exposure ranges from three to four months. In contrast, the maxilla, characterized by comparatively lower bone density and trabecular architecture, necessitates an extended healing duration of four to six months to ensure adequate osseointegration before surgical intervention **[12]**.

Techniques in second-stage implant surgery:
Full-thickness flap (conventional technique):
A crestal mucoperiosteal flap is reflected to expose the implant, allowing removal of the cover screw and placement of the healing abutment before flap closure with sutures. It provides excellent access for assessing osseointegration, removing granulation tissue and modifying keratinized attached gingiva (KAG). However, it is associated with greater surgical trauma, postoperative discomfort and longer healing **[13]**.

Tissues punch (flapless technique):
A biopsy punch removes a circular plug of mucosa directly over the implant, enabling quick placement of the healing abutment without sutures. It is minimally invasive, reduces bleeding and healing time and is ideal when sufficient KAG is present. Its main limitation is permanent loss of keratinized tissue **[14]**.

Laser-assisted technique:
Diode, Er: YAG and Nd: YAG lasers are used to uncover implants by ablating soft tissue with simultaneous hemostasis. Advantages include minimal bleeding, reduced pain, rapid

healing and no sutures. However, tissue is sacrificed, flap repositioning is not possible and improper laser settings may cause thermal damage to the implant **[15]**.

Partial-thickness (split-thickness) flap:
This technique preserves the periosteum while reflecting only the superficial soft tissues, allowing greater flap mobility. It is particularly useful for apically repositioning tissue to increase the width of KAG while maintaining blood supply **[16]**.

Partial-thickness flap with connective tissue graft:
A subepithelial connective tissue graft from the palate is placed beneath a split-thickness flap to augment peri-implant soft tissue volume and KAG, especially in aesthetic areas. Although effective, it requires a donor site, increases surgical complexity, operative time and patient morbidity **[17]**.

Surgical guide–assisted technique:
A digitally or conventionally fabricated surgical guide accurately localizes submerged implants, enabling tissue punch or minimal-incision uncovering with precise healing abutment placement. It improves accuracy, preserves keratinized tissue and is especially beneficial for multiple or anatomically complex implants, but requires additional planning, fabrication costs and technical expertise **[18]**.

Recent advances and emerging techniques in second-stage implant surgery:
The landscape of second-stage implant surgery has evolved considerably in recent years, with the introduction of several innovative techniques aimed at minimizing surgical trauma, enhancing procedural precision and improving overall patient comfort. Among the most notable advancements are apex locator–guided implant uncovering, ceramic bur–assisted tissue exposure and laser-assisted minimally invasive surgical approaches. These techniques collectively represent a paradigm shift from conventional flap-based procedures toward less invasive, more patient-friendly protocols without compromising clinical outcomes **[19].**

Apex locator-assisted technique:
The apex locator–assisted technique represents a novel and cost-effective method for intraoperative implant localization, leveraging the electrical resistance detection. In this technique, the apex locator probe is placed in contact with the mucosal surface overlying the implant site and variations in electrical resistance are utilized to precisely identify the position of the implant platform beneath the soft tissue. A minimal incision is subsequently made directly over the detected site, facilitating targeted and atraumatic implant uncovering **[20].** This approach offers the distinct advantages of high localization accuracy, minimally invasive execution and cost-effectiveness, given that it repurposes an instrument already available in most dental clinical settings. Nevertheless, the technique requires a consistently dry operative field for accurate readings and remains sensitive to operator technique, both of which may limit its predictability in routine clinical application **[21]**.

Implant locator device technique:
Specialized implant locator systems have been developed to enable precise intraoperative detection of the implant platform, facilitating accurate and targeted surgical exposure. In this technique, the locator device is employed during surgery to identify the exact position of the implant, thereby guiding the placement of the incision directly over the implant platform with a high degree of spatial accuracy **[22]**. This precision-guided approach serves to minimize unnecessary soft tissue disruption, reduce overall surgical time and improve the reproducibility of the uncovering procedure. The principal advantages of this technique include enhanced accuracy, reduced operative duration and minimization of collateral soft tissue trauma **[23].**

Ceramic bur-assisted implant exposure technique:
The ceramic bur–assisted implant exposure technique constitutes a minimally invasive surgical approach in which a ceramic surgical bur is employed to selectively remove the soft tissue overlying the submerged implant, without necessitating conventional flap reflection. Through careful and controlled application of the ceramic bur, the cover screw is progressively exposed, following which a healing abutment is placed to initiate soft tissue maturation and contouring. The use of a ceramic bur confers a significant advantage over conventional metal instrumentation by substantially reducing the risk of thermal injury to the surrounding peri-implant tissues, while simultaneously affording the clinician a high degree of control during tissue removal **[24, 25]**.

Complications of second-stage surgery:
Stage II surgery, while generally a minor procedure, is not without risk. Potential complications include postoperative infection, premature healing abutment loosening, soft tissue hyperplasia around the healing component and in cases of flap-based approaches, wound dehiscence. Systemic conditions such as diabetes mellitus, active smoking, or immunosuppression can impair healing and increase complication rates **[26]**. Failure to achieve the anticipated KAG outcome after flap-based Stage II surgery may necessitate subsequent free gingival graft procedures. In cases of soft tissue hyperplasia around healing abutments- commonly seen with non-engaging or shallow healing components in thick tissue biotypes- gingivoplasty or abutment exchange may be requireds**.** Thermal damage from electrosurgery or laser use remains a rare but important risk, particularly when these instruments approach the implant body **[27].**

Conclusion:
Second-stage implant surgery plays a crucial role in peri-implant tissue healing, esthetics and long-term implant success. Appropriate surgical technique selection and adherence to biological principles improve tissue stability and clinical

predictability. Modern minimally invasive approaches may reduce postoperative morbidity and enhance patient outcomes.

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