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FEATURES OF PERFORMANCE AND POSSIBLE COMPLICATIONS OF IMMEDIATE DENTAL IMPLANTATION UNDER COMPLEX ANATOMICAL CONDITIONS

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Dental implantation is one of the most advanced methods of restoring missing teeth. Depending on the timing of implant placement after tooth extraction, immediate and delayed dental implantation are distinguished. Delayed dental implantation is a classical approach, involving the placement of a dental implant 4 to 6 months after tooth extraction. Immediate dental implantation refers to the placement of the implant directly after the extraction procedure. This literature review examines techniques for immediate dental implantation in cases with complex anatomical conditions and analyzes possible complications that may arise both intraoperatively and in the long-term postoperative period.

Key words: dental implantation, complex anatomical conditions, tooth extraction, bone plastic, adentia.

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ОСОБЛИВОСТІ ПРОВЕДЕННЯ ТА МОЖЛИВІ УСКЛАДНЕННЯ ОДНОМОМЕНТНОЇ ДЕНТАЛЬНОЇ ІМПЛАНТАЦІЇ ЗА СКЛАДНИХ АНАТОМІЧНИХ УМОВ

Дентальна імплантація являється найсучаснішим методом відновлення втрачених зубів. За терміном встіновлення дентального імплантанту після операції видалення зуба виділяють одномоментну та відстрочену дентальну імплантацію. Відстрочена дентальна імплантація є класичною методикою, яка передбачає встановлення дентального імплантанту через 4–6 місяців після операції видалення зуба. Одномоментна дентальна імплантація передбачає встановлення дентального імплантанту відразу після видалення зуба. Проведено огляд літератури щодо методик проведення одномоментної дентальної імплантації за складних анатомічних умов, а також можливих післяопераційних ускладнень, які можуть виникати як інтраопераційно, так і у віддалений післяопераційний період.

Ключові слова: дентальна імплантація, складні анатомічні умови, видалення зуба, кісткова пластика, адентія.

The study is a fragment of the research project "Algorithm for comprehensive treatment of inflammatory processes and prevention of pathological scar formation on the skin of the head and neck following planned and emergency surgical interventions", state registration No. 0124U000093.

Currently, one of the optimal methods for replacing dental arch defects is dental implantation. Dental implants can restore both a small defect (1–2 teeth) and complete jaw edentulism. Scientists and practicing physicians are continually working to improve and simplify both the surgical stage of dental implantation and subsequent orthopedic rehabilitation [13].

A special place among the techniques of the surgical stage of dental implantation is occupied by immediate implantation. This technique involves placing an artificial tooth root (dental implant) right after

a tooth is surgically removed. The method has several advantages. These include shortening the overall recovery time for patients. With advanced imaging and planning tools (digital diagnostic and planning methods), it is possible to attach a temporary artificial tooth (orthopedic structure) during the same procedure. Other benefits include maintaining the bone around the implant, shaping the surrounding soft tissue (gum) to achieve a natural appearance, and reducing the number of separate surgical procedures required [21].

Immediate dental implantation demands careful planning, surgeon expertise, adherence to protocols, and the absence of inflammation. Achieving primary implant stability is harder, and postoperative edema and pain occur more often than with delayed implantation [26].

Anatomical conditions in the surgical area are crucial and can significantly complicate or even prevent dental implantation. A clear understanding of maxillofacial anatomy and the ability to identify complex conditions are essential for planning and performing dental implantation. These skills help reduce or even avoid certain postoperative complications, greatly increasing the success rate and quality of dental implantation.

Dental implantation is an effective and predictable treatment that restores both full function and aesthetics. However, complications can arise during or after surgery. Causes include patient anatomy, concomitant diseases, surgical protocol violations, or planning errors [43].

The purpose of the study was to systematically review the current literature on surgical techniques for dental implantation under complex anatomical conditions, with an emphasis on associated complications and their preventive measures.

A literature search and analysis of publications in the National Scientific Medical Library of Ukraine, the electronic database of medical publications PubMed, Google Scholar, Web of Science, and other authoritative medical literature databases via the Google search engine were conducted. Publications from the period 2019 to February 2025 were included. The inclusion criteria were: “Dental implantation”, “Immediate dental implantation”, “Complications of dental implantation”. In case of duplicates and irrelevant articles, they were excluded from the study.

Complex anatomical conditions may require additional surgical procedures. Sometimes, these are performed during dental implantation. In other cases, extensive interventions with long, costly rehabilitation are necessary [3].

Complex anatomical conditions for dental implantation include:

– Significant bone tissue atrophy;

– Proximity to anatomical structures (maxillary sinus, mandibular canal);

– Pathological changes in the soft tissues in the implantation area include significant gingival recession, the presence of scar changes, and insufficient volume of keratinized attached gingiva.

When performing the surgical stage of dental implantation in the maxillary molar area, the proximity of the maxillary sinus often complicates or prevents implantation [4]. In such cases, a “sinus lift” is performed: the floor of the sinus is lifted, creating space for bone grafting and later placement of a dental implant [6]. There are closed “sinus lift” techniques (through the socket of the extracted tooth or through the osteotomy site) and open techniques (requiring a “window” in the outer wall of the sinus for surgical access) [12].

The presence of a sufficient volume of keratinized attached gingiva in the implantation area is a crucial factor for the long-term stability of dental implants [2]. Keratinized attached gingiva plays an important functional role. It provides a barrier function, as the dense structure of keratinized gingiva serves as an effective barrier preventing the penetration of bacteria and other pathogenic factors into the peri-implant tissues. The presence of attached keratinized gingiva ensures the stability of the gingival margin position and prevents its apical displacement and recession, which is especially important in the aesthetic zone. This ensures better hygiene and reduces the risk of bone resorption in the area where the dental implant is installed [25]. Research demonstrates a direct link between insufficient width of keratinized gingiva and the development of peri-implant diseases. A minimum sufficient width is considered to be 2mm of keratinized gingiva around the dental implant to maintain healthy peri-implant tissues. In the absence of sufficient soft tissue volume, flap operations are performed using autogenous tissues (grafts from the maxillary tuberosity or palate), collagen membranes, and PRF technologies [18].

Surgical guides in dentistry facilitate precise planning and placement of dental implants. They improve implant accuracy and lower trauma risk to anatomical structures [17]. Pilot drilling guides only the initial, smallest drill, while full guidance guides control all drills and the implant driver, ensuring the most precise implant placement in the planned position [15].

In case of insufficient horizontal bone volume, guided bone regeneration using bone blocks or the alveolar ridge splitting (ARS) procedure is recommended. ARS is a surgical procedure that splits the cortical bone to expand bone volume. This makes dental implant installation possible. The advantages include reduced treatment time, lower infection risk, and high predictability [39]. However, complications can occur. The most common are fractures of the alveolar process, usually seen with a narrow (less than 3mm) alveolar process, and possible paresthesia or inflammation in the surgical area.

Alveolar ridge splitting, a technique to widen the jawbone, can also be performed in the presence of insufficient horizontal bone volume [21]. In addition to these techniques, bone grafting is also used, performed by taking bone blocks from the area of the mandibular angle (the back corner of the lower jaw) or the chin (front of the lower jaw) [22].

Complex anatomical conditions in the dental implantation area increase postoperative risks [23]. Surgeons should be aware of potential complications and strive to minimize their occurrence during surgery. Patients must also be informed about possible complications and the steps to take if they occur [14]. Complications can lengthen rehabilitation, increase costs, and may result in the complete loss of the implant.

Complications after immediate implantation are divided by time:

– Complications in the immediate postoperative period (the first 7–10 days after surgery);

– Complications in the late postoperative period.

By localization, complications are classified as local (in the surgical area) and general (outside the surgical area, potentially affecting adjacent topographic-anatomical areas) [5, 8]. Immediate postoperative complications include bleeding. This may occur during surgery or within several days following the procedure. Causes include vessel trauma during manipulation, coagulation problems, or anticoagulant use [20]. To prevent bleeding, it is essential to collect anamnesis carefully and exercise extreme caution at all stages of intervention [7].

Postoperative edema is a normal reaction to trauma, but its occurrence on days 5-7 may indicate the development of an inflammatory process, which can lead to peri-implantitis and subsequent implant rejection [1]. The occurrence of hematomas is also possible due to trauma to soft tissues or after vascular injury during anesthesia, tooth extraction, or osteotomy preparation. To reduce edema or prevent its occurrence, a cold compress is recommended immediately after dental implantation, as well as the prescription of anti-edema medications [28].

Suture dehiscence can occur due to non-compliance with suturing techniques, trauma to the postoperative area by the patient, or excessive tension on the wound edges beyond the limits of plastic deformation [29]. If not eliminated in a timely manner, it can lead to impaired wound healing, formation of soft tissues around the implant, or even its rejection. To prevent this, patients are advised after surgery not to eat hard food and to brush their teeth carefully, especially in the area of dental implantation [16].

Paresthesia is a sensory disorder manifested by numbness, tingling, or dysesthesia in the area of nerve innervation. Paresthesia can occur due to nerve compression directly by the implant body or as a result of postoperative edema [31]. Trauma to peripheral nerve endings or direct mechanical damage to the nerve trunk by the implant body or surgical instrument is also possible [47]. One of the causes of paresthesia is thermal necrosis, which can occur due to non-compliance with the irrigation cooling protocol during osteotomy preparation. In most cases, this complication resolves on its own; however, with persistent loss of sensitivity, it may be necessary to remove the implant that causes nerve compression after placement [27, 48]. To prevent this complication, it is essential to approach the planning stages of dental implantation carefully, especially in cases where the extraction socket is close to the mandibular canal. Additionally, it is crucial to be extremely cautious when reflecting soft tissues, particularly in the area of the mandibular premolars. The use of navigational guides also helps prevent this complication [11].

Dental implant surgery in the area of the maxillary molars can often be complicated by the close proximity of the maxillary sinus to the surgical site [32]. This complication can arise from traumatic extraction or as a result of bone resorption of the alveolar process of the maxilla due to long-term edentulism [44]. In the presence of such anatomical conditions, a “sinus lift” operation is necessary, during which the floor of the maxillary sinus is lifted, the resulting space is filled with osteoplastic material, and subsequent immediate or delayed placement of a dental implant is performed [9]. There are two main techniques for performing sinus lift surgery:

– An open sinus lift, which involves using a vestibular approach to the maxillary sinus (through the oral vestibule), is more often used in cases of significant atrophy of the alveolar process.

– Closed sinus lift, which uses a transalveolar approach to the maxillary sinus (through the extraction socket or the alveolar process of the maxilla).

Despite the high success rate of sinus lift surgery, predictable subantral bone gain, and high dental implant survival rates, both intraoperative and postoperative complications can occur. The most common intraoperative complication of open sinus lift is perforation of the Schneiderian membrane during its detachment and reflection from the bony walls of the sinus [33, 42]. It is reported that the occurrence of this complication ranges from 6 % to 42 %, but most publications report rates between 20 % and 25 %. The occurrence of this complication is most often associated with the thickness of the Schneiderian membrane mucosa, insufficient surgeon experience, and individual anatomical features of the maxillary sinus and alveolar process of the maxilla. The treatment of this complication depends on the size of the perforation [34]. For small and medium-sized defects, a resorbable membrane is placed to cover the communication. For significant defects, termination of the surgical intervention is recommended, and a repeat sinus lift should be performed no earlier than 6-8 weeks later [45]. The occurrence of rhinosinusitis after surgery is also possible [40]. The literature describes chronic rhinosinusitis as a complication that can occur after a sinus lift procedure, resulting from infection of the graft or dental implant [49]. Statistical data indicate that the frequency of this complication ranges from 4.2 % to 8.4 %. However, the treatment of chronic rhinosinusitis is complex and may require removal of the graft and dental implant [19].

Complications in the late postoperative period also include implant rejection, which can occur due to an inflammatory process, insufficient primary stability of the implant, or trauma to the surgical site [10].

The condition of the tissues around the implant is important for the long and stable service life of the dental implant. Peri-implant diseases, such as peri-implant mucositis and peri-implantitis, are inflammatory conditions [36]. Peri-implant mucositis is considered a precursor to peri-implantitis. Early detection and treatment of these diseases play a crucial role in ensuring the long-term and stable service of dental implants [41]. Clinical signs of peri-implant mucositis are inflammation of the mucosa and the absence of bone resorption in the peri-implant area; this disease may be accompanied by gingival bleeding, exudate discharge, and the formation of periodontal pockets in the peri-implant area. Peri-implant mucositis occurs due to the formation of microbial biofilm around the dental implant and can be reversible after biofilm removal [37].

Peri-implantitis is an inflammatory process of the peri-implant tissues, characterized by progressive loss of bone volume around the implant [38, 39]. Peri-implantitis can occur due to patient non-compliance with personal hygiene norms, an incorrectly manufactured orthopedic structure, or errors during the planning and surgical stage of dental implantation [46]. Symptoms of peri-implantitis also include pain and redness of the mucosa, formation of periodontal pockets in the intervention area, and possible exudate discharge. To prevent this complication, complete patient sanitation before surgery is necessary, as well as strict adherence to aseptic norms, and prescription of adequate antibiotic therapy as needed [30].

Conclusion

Analysis of literary data has shown that immediate dental implantation is a predictable and physiologically justified technique that significantly reduces overall treatment time and preserves the volume of alveolar bone tissue. However, its performance under complex anatomical conditions substantially increases the risk of both early and late postoperative complications. A key success factor is thorough planning of the surgical intervention with mandatory use of computed tomography and surgical guides. To overcome complex anatomical conditions, it is necessary to perform additional surgical interventions (sinus lift, alveolar ridge splitting surgery, guided bone regeneration, and soft tissue grafts). The choice of technique depends on the individual characteristics of the patient and the nature of the defect. The most common complications are: perforation of the Schneiderian membrane, bleeding, trauma to nerve endings, edema, pain syndrome, suture dehiscence, peri-implantitis, and implant rejection. Their prevention directly depends on adherence to surgical safety protocols, adequate antibiotic prophylaxis, and thorough hygiene. The successful performance of immediate dental implantation under complex anatomical conditions requires a high level of surgical qualification, the use of modern diagnostic and planning methods, and strict patient compliance with postoperative recommendations. It is necessary to update and improve the protocols for performing the surgical stage of dental implantation under complex anatomical conditions to enhance the predictability and success of the surgical intervention, reduce the risk of potential postoperative complications, and optimize outcomes at the stage of orthopedic rehabilitation. Further research should focus on enhancing techniques for bone and soft tissue grafting, minimizing the trauma associated with surgical interventions, and developing new algorithms to improve the predictability of outcomes.

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