Complications During Surgical Insertion of Miniimplants

Powikłania podczas umieszczania miniimplantów

Abstract

Miniscrews have been introduced as a temporary cortical anchorage device in orthodontic treatment. Despite all the advantages, miniscrews are burdened by some complications. Treatment with miniimplants can fail for various reasons, including improper surgical techniques during placement. The possibility complication during surgical insertion are: dental root, blood vessels and nerves injuries, perforation of maxillary sinus and nasal cavity, miniimplant instability and fracture, slippage. Fortunately, proper proceeding during implantation may reduce or even eliminate potential complication. The aim of this article was to consider complications that occur during the insertion of miniimplants (Dent. Med. Probl. 2011, 48, 1, 11–18).

Key words: orthodontic miniimplants, implantation, complications.

Streszczenie


Słowa kluczowe: miniimplanty ortodontyczne, implantacja, powikłania.

For many years methods of maximum anchorage to prevent undesirable movement of anchorage teeth have been searched. Anchorage is a critical and important issue in successful orthodontic treatment [1]. Commonly used methods do not eliminate the movement of the anchoring teeth, may cause some side effects and therapeutic success is often dependent on cooperation with the patient. In 1997 Kanomi [2] described miniimplants – titanic screws designed for orthodontic purpose. Since that time miniscrews have been introduced as a temporary cortical anchorage device (TCAD) in orthodontic treatment – intraoral, extradental and indirect anchorage. The term TCAD describes all sorts of screws, implants, pins, posts and onplants used to provide skeletal anchorage and removed after ending of therapy and usually made of titanium alloy [3]. In contradiction to the prosthetic implants, osseointegration of orthodontic miniscrews is undesirable.

TCADs enable corrections of vertical (eg. intrusion of incisors in deep bite malocclusion or molar intrusion in open bite malocclusion) and antero–posterior positions (eg. protraction of posterior teeth, retraction of anterior teeth or molars distalization in class II malocclusion) of teeth [4]. Miniscrews are also inserted whenever dental displacements are essential and the orthodontic therapy based on miniimplants can precede prosthodontic therapy.
There are two types of miniimplants [5]. Self-tapping ones are inserted into a guide-hole, which is made by a drill bit (pre-drilling method). Self-drilling ones, used in the drill-free method, are inserted directly into the intact cortical bone [6].

They have a lot of advantages such as: small size, versatility, no need for laboratory work, possibility of immediate loading, easy insertion and removal, independence on patient’s cooperation, treatment time reduction, patient’s comfort and relatively low cost [6–10]. Despite all the advantages miniscrews are burdened by some complications. Treatment with miniimplants can fail for various reasons including improper surgical techniques during placement [11]. The aim of this article was to consider complications that occur during the insertion of miniimplants.

**Systemic Complications**

Surgical technique of the TCAD is simple and requires only a local anesthetsia. Most complications that may occur during any surgical procedure are minor. Occasionally, systemic complications may occur which can lead to life-threatening situations [12]. These medical emergencies such as cardiac or respiratory arrest are usually unexpected and rare. Despite this, every doctor should know and follow basic life support skills. In order to avoid complications and undergo an effective treatment with miniscrew, every patient should be questioned on their medical and dental history. Detailed information should be obtained on respiratory and cardiac diseases, diabetes, current and past drugs intake (including steroids, anti-coagulants), pregnancy, drug allergies, excessive bleeding after injuries, previous general and local anaesthetic experience.

Theoretically, during placing of a miniscrew into the palate, the miniscrew may be accidentally swallowed or inhaled. This situation may occur due to a sudden movement (especially at nervous patient or in case of inadequate depth of anesthesia), especially without adequate airway protection. This may cause the need for gastroscopic or bronchoscopic removal of a foreign body.

**Dental Root Injury**

Miniscrews are usually placed interradicularly. Improper placement of miniscrew runs a risk of accidental injury of the dental root and periodontium or bone damage. Sometimes root wounding provides loss of tooth vitality, root resorption, dentoalveolar ankylosis or osteosclerosis [13–16]. Healing of the periodontal structure is possible when the root injury is limited to the cementum or the dentin [14–15].

Histological examination showed an almost complete repair of periodontal ligament, cementum and bone in 12 weeks after removal of the miniimplant [15]. Under unfavorable conditions (such as pulp invasion or inflammatory infiltration), regeneration of the damaged attachment apparatus and healing process is interrupted [14]. Cheng et al. [17] suggested that the risk of infection significantly increases when screws are placed into the alveolar mucosa. Invasion of the pulp chamber allows access of the pathogens which may lead to the root resorption, bone destruction and tooth de-vitalization. This situation can require extraction if endodontic treatment of the injured tooth fails [14]. Some orthodontists recommended manual insertion for a good tactile control [18] and possibility to sense when the implant touches the root. If during manual insertion clinician notices increase in resistance, he should back out and redirect the implant [19]. Position after insertion may be controlled by radiographic examination – periapical radiograms in two oblique and one perpendicular projections [20]. Unfortunately, errors and distortions in parallel technique of radiograms could produce “false negative” and “false positive” pictures.

Various recommendations are suggested for TCAD placement to protect surrounding structures, from 1.0 mm between the periodontal ligament and the miniimplants, 2.5 mm of bone around the TCAD, to 5.0 mm between adjacent roots of TCAD. To allow displacement up to 1.5 mm of miniscrew during loading Liou et al suggested minimal distance of 2.0 mm between the root and the TCAD [13].

There are also general guidelines – a map of safe zones – during the placement of miniscrew but they do not include individual differences in anatomical structures and root morphology [21–22]. Kyung-Seok et al. [23] recommend the safest area for miniscrew placement as space between second premolar and first molar 6–8 mm above the cervical line in the maxilla and between a first and second molar, less than 5 mm from the cervical line in the mandible.

**Perforation of Maxillary Sinus and Nasal Cavity**

Perforation of a maxillary sinus is a rare complication during placement of TCADs. Maxillary sinus floor elevation anteriorly extends to the canine and premolar area. The apices of the molars and premolars can penetrate or touch this
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Blood Vessels and Nerves Injuries

Also blood vessels and nerves can be injured during the miniscrew placement. Those occur rare, as vessels and nerves generally lie away from insertion sites [37]. An ideal implant position is in a non-tooth-bearing site, without any pathway or foramen of major blood vessels and nerves [27]. Increased care should be taken in particular regions on the palatal slope such as the pathways of the nervus palatinus major, the arteria palatina major and nervus incisivus. Also the retromolar region, the retromolar pad and buccal dentoalveolus in the mandible, places where the nervus and arteria alveolaris inferior, the nervus and arteria mentalis, the long buccal nerve and the lingual nerve are localized, should be embraced as particular regions of nerves and blood vessels injury [38]. The toughest bone and specific shape of the mandible in the retromolar area require much attention during implantation to prevent injury to the mandibular canal which is close to this area and the lingual nerve travels on the inner side of the ramus.

It is preferable that implantation and surgical extraction of an impacted third molar are performed together. Flap surgery increase visibility and accessibility of the retromolar area. Predrilling bone can reduce the risk of miniscrew fracture and surgical trauma.

Placement of TCADs in the palatal slope risk potential damage of the greater palatine nerve and the greater palatine artery. To minimalize this miniscrews should be inserted mesially to the second molar in the palatal slope [25, 31, 39].

Nerve injury may result in parasthesia, dysesthesia, anesthesia or combination of the symptoms. Usually, nerve damage heals spontaneously without medications, with gradual regeneration of sensation in several weeks or even months. But if the symptoms do not diminish in 8 weeks, patients require pharmacotherapy: B group vitamins, NSAID, corticosteroids, antihistamine, vasodilators, diuretics, laser therapy or in same cases microneurosurgery with the nerve decompression and grafting [40–41].

To avoid this complication various methods have been attempted, among which are proper radiographic planning and placement technique and localization of miniscrews. Investigations allowed to create special anatomical maps to determine safer locations and control insertion angle [42–43]. The literature advises to use radiographic examination before microscrew anchorage, which provides a topographical survey of the anatomical structures. The most common techniques are panoramic and periapical dental radiographs. Orthopantomography provides information about bone quality and density, root angulation and localisation of vessels, nerves, sinus spaces, and dental germs in growing patients [42]. Same orthodontist recommended using computed tomography before insertion to show all structures for...
the three space levels [21]. It is suggested to use a surgical guide when miniscrews are placed near delicate anatomical structures such nerve, sinus or root to precisely locate the vector and the placement point [44].

**Miniimplant Instability and Fracture**

Primary stability is the screw’s initial anchorage in the bone. It is essential, as orthodontic miniscrews are loaded immediately after the insertion [45]. The factors that influence primary stability are: insertion modalities, bone quality and implant design. Lack of primary stability usually leads to progressive miniscrew mobility and failure [46–47]. High insertion torque has been attributed to high primary stability of miniimplant [48]. A smaller pilot hole diameter may increase insertion torque but also may lead to screw fracture [49]. To achieve maximum primary stability and minimize the possibility of screw fracture, the ideal size of pilot drilling should be considered carefully and individually to each screw type. The diameter of a pilot hole should be adequate to the screw’s diameter and length and the bone’s quality. It is recommended that the diameter of the pre-drill hole is 80% of the screw diameter or match the thread’s internal diameter [50]. It is also believed that other screw factors such as diameter, length, screw thread form are also important for initial stability [51].

Florvaag et al. reported that initial stability improved after drill-free method [47]. Miniscrew stability can be affected also by microcracks in the bone formed during the placement as a result of increased torsional stress. Self-drilling TCAD, larger diameter and conical or tapered shape might cause overcompression by excessive torque. This can lead to microdamage to the cortical bone [47, 52]. TADs placed at a higher torque may produce high stress, therefore to achieve higher success, a lower implant placement torque (5–10 Ncm) is suggested [56]. It is believed that the majority of primary stability of TCADs comes from cortical bone, with lesser degree by medullary bone [54]. “High angle” patients tend to have thinner buccal cortical bone. In this case or when the place of insertion has inadequate amount of compact bone, it is recommended to use a bigger miniimplant [55]. Another reason for inadequate primary stability are pilot hole overenlargement and pilot drill overheating [56]. The main reason for too large predrilled passageway is the orthodontist’s inability to hold the handpiece stable and keep a drill in one and same plane without lateral movement during drilling. If primary mobility is present at the time of placement, then relocation should be considered immediately.

The miniimplants should exhibit biocompatibility, excellent corrosion resistance and mechanical strength. Mechanical strength must be enough to resist torsional stresses developed during placement and removal. Despite the development of technologies and rising experience with miniscrew treatment, fracture of miniscrew implants during placement or removal may occur [57]. It seems that this is largely related to the morphologic design of the implant [58] and the strength of titanium or a titanium alloy, which depends on its microstructure. Microstructure is influenced by the machining process of the miniimplants, heat treatment and composition [58]. Screws with a smaller diameter are easier to inserted between the roots. Unfortunately a small decrease in diameter significantly increases the torsional strength and the risk of fracture especially in the thick cortical bone of the mandible [10]. Park et al. [38] in order to minimize the risk of fracture recommends use of screws with a diameter of 2 mm or more and a steady implantation technique. Others have argued that in order to avoid this complication a pilot hole should be made in dense cortical bone, even for self-drilling miniscrews and placed slowly and with minimal pressure [59]. A smaller pilot hole diameter may be used to increase insertion torque, thus improving primary stability but may cause of screw fracture. To achieve maximum primary stability and minimize the risk of fracture, this dimension should be considered individually to each screw type [47]. Also the long mini-implant may provide higher stability but they may break due to high insertion torque [64]. In the case of miniscrew fracture at the level of the bone, it may be advisable to leave the screw in place. The orthodontist should place a new miniscrew in the site adjacent to the fractured miniimplant. After the surgery postoperative radiograph is performed [29].

**Other Complications**

There are same areas of increased cortical bone thickness and density. The densed structure of the bone with heavy forces during implantation lead to problems during initial insertion, because of slipping miniscrew along the periosteum [50]. Critical regions include the buccal cortical shelf, the zygomatic buttress, the retromolar pad, mandibular buccal alveolar region, the maxillary buccal exostosis. In this cases even placing a self-drilling TCAD may require pre-drilling. Some clinicians make a pit perpendicularly in the cortical
bone with a small round or fissure bur before using pilot drilling. The others begin insertion at an obtuse angle to create a purchase point with the tip of the TCAD. Then, after TCAD reach the cortical bone steepen the angle to complete the insertion [31, 61]. Steeper angulation (< 30 degree) increases the risk of slippage but minimizes the risk of root injury [31].

Fibrous capsulation of the screw, bone necrosis and implant failure may be caused by excessive surgical trauma and thermal injury [62]. Self-drilling miniscrews have cutting flutes at the tip to cut bone that allows screw to enter the bone. Some orthodontists made also a pit perpendicular in cortical plate using round burs before insertion. These procedures should be done with saline cooling [3] and judicious care to prevent the bone from overheating, because most of the energy is not used in the cutting process but it is transformed into heat. A temperature over 47 degree only for more than 1 minute leads to bone necrosis [63]. The amount of friction is dependent on the thickness and density of the cortical plate where the TCAD must be placed. In the mandible, where this layer is thicker and more dense than in maxilla, more friction and heat are created [11].

Sometimes miniscrew is needed to be inserted in the place covered by unattached gingiva. In this case a tissue punch or cutting off the mucosa and peristome should be performed, because of tendency to wind around the pillot drill or the body of miniscrew which causes soft tissue injury and trauma [64].

Subcutaneous emphysema arises from the introduction of air or other gases into soft tissues [65]. It is caused by high pressure air instruments, air-water syringes, air-driven, high-speed handpieces or spray or jet devices [66–67]. Gaseous invasion may be restricted to the connective tissues immediately adjacent to the entry site, but passage and accumulation of air between tissue spaces or fascial planes may also lead to tissue-space emphysema [68]. The specific symptoms are: immediate mucosal swelling with crepitus [69], the absence of erythema, which appears in a few seconds or minutes after air has entered the submucosal space significant tenderness, or lymphadenopathy edema [68]. Additionally patient may also experience other symptoms such as mild discomfort, cervicofacial and orbital swelling, airway obstruction with difficulty in breathing, ear pain, hearing loss, interproximal and interseptal alveolar necrosis [70], intense dysphonia (whispering and husky voice) [68], optic nerve damage [67], sometimes pain caused by tension present in tissues [71]. The differential diagnosis should consider allergic reaction, angioedema, hematoma and infection. During a sudden swelling an allergic reaction should be considered [67]. To avoid these unpleasant complications, implantation should be made with a slow-speed and low-pressure, for both drilling a pilot hole through the mucosa and purchasing a point. Excessive bleeding and salivation should be removed with a sterile gauze or a suction. Particular care should be taken when placing implants in the deep gum pockets [65], and several regions: maxillary zygomatic, buccal mandibular posterior and retromolar one. By the time swelling appears, all performed procedures should be discontinued. Depending on the area, the suitable X-rays are taken: periapical, pantomographic, head and neck, in order to confirm the diagnosis and determine extent of the changes [65]. In cases of mild to moderate emphysema treatment is limited to reinsurance and observation of the patient [72]. To prevent secondary infections prophylactic administration of antibiotics is recommended (preferentially amoxicillin with clavulanic acid) [73]. After 5 to 10 days the majority of patients resolve spontaneously. However, in some cases, emphysema may lead to the development of symptoms of potentially life-threatening [65]. Patient should not perform activities that increase the intraoral pressure, such as blowing nose or playing musical instruments [74]. The literature describes subcutaneous emphysema, pneumomediastinum, pneumopericardium, and pneumothorax as complications following dental procedures [75]. In case of thorax and back pain a thorax X-ray should be also performed [76].

TCADs are very helpful in obtaining anchorage especially in non-compliance patients. With the possibility of therapeutic gain increasing recognition and use throughout the world, often solving therapeutic problems, which hitherto have been the cause of failures in treatment. Despite the multitude of possible complications, they rarely occur and produce permanent, irreversible damage or health problems. The surgical technique is simple and does not require the use of multiple tools. Through clinical and experimental trials, technique and mechanical properties of miniimplants are continuously improved. Proper proceeding during implantation may reduce or even eliminate potential complication.
References


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