MAXILLOFACIAL OSTEOTOMY UTILIZING NAVIGATION GUIDES DURING DENTAL SURGICAL PROCEDURES

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Osteotomy is a procedure that requires particular attention regarding bone tissue management due to its inherent risk of trauma. As documented in the literature, this risk is driven by mechanical damage, drilling duration, and thermal effects on the bone [1–4]. Currently, surgical dentistry actively utilizes surgical navigation guides (templates) to significantly enhance the accuracy and safety of interventions such as dental implantation, bone grafting, and tooth-preserving surgeries. The implementation of these templates has improved procedural precision and reduced the invasiveness of the interventions. However, their utilization requires non-standard osteotomy parameters, primarily due to the limited access of irrigation fluid to the drilling site. A minimal clearance gap between the sleeve guide and the rotating component of the instrument results in an increase in drill temperature due to friction. Consequently, this can distort the clinician's assessment of the actual pressure applied by the instrument onto the bone tissue. Failure to adhere to osteotomy guidelines, even when utilizing navigation guides, can lead to tissue inflammation and necrosis within the operative zone. Data regarding scientifically substantiated protocols for jaw osteotomy during dental surgical procedures utilizing navigation guides have not yet been widely disseminated.

This study aims to identify the biophysical characteristics of osteotomy under conditions involving the use of surgical navigation guides in surgical practice.

Materials and Methods

To conduct this study, scientific publications available in the PubMed/Medline, eLibrary.ru, disserCat, and CyberLeninka databases were reviewed. The literature search spanned from 1953 to 2021 and covered topics related to osteotomy, specifically: thermal characteristics of bone during drilling, osteotomy protocols, surgical templates, irrigation challenges in guided surgery, guide sleeves for templates, and instruments utilized in template-guided surgery.

Results and Discussion

An analysis of the existing literature demonstrates that most studies focus on the characteristics of osteotomy in dental surgery without the application of surgical navigation guides. A critical aspect of osteotomy, besides mechanical impact, is the thermal regimen of the bone. The rise in temperature is determined by factors such as the rotational speed of the bur, the duration of the procedure, and the force applied to the instrument.

Even when an osteotomy is performed correctly, it can still induce bone tissue necrosis, which normally reaches a depth of 0.4-1.5 [5]. However, if the procedure involves excessive trauma or force, the depth of necrosis can reach up to 17.5 mm, which in turn triggers intensive bone destruction and the development of osteomyelitis [4].

An increase in bone temperature by 4-5leads to accelerated blood flow within the bone marrow. When heated by 10-13 (above the baseline physiological temperature), irreversible changes in collagen occur, accompanied by the disruption of bonds between collagen fibers and hydroxyapatite, as well as the resorption and necrosis of distinct bone elements [6]. Temperatures exceeding this 10-13 threshold lead to protein denaturation, osteoblast death, prolonged microcirculatory impairment lasting 4–5 weeks, and sequestrum formation. During osteotomy, the maximum permissible temperature increase of the bone at the drilling site must not exceed 7 The heating of bone during drilling is caused by friction, the intensity of which is determined by the rotational speed and geometry of the cutting tool. The low thermal conductivity of bone tissue, combined with the compromised evacuation of bone debris (shavings) from the osteotomy site, further exacerbates localized temperature spikes [7].

To prevent bone overheating, manual preparation or hand drills can be used; however, while this method eliminates thermal issues, it does not guarantee minimal trauma. Manual preparation can result in severe mechanical damage, microfractures, and compression of adjacent bone tissues, which induces fragmentation, resportion, and delays bone regeneration. Consequently, machine-driven preparation with a rotational speed ranging from 800- 2500 is preferred. Furthermore, the geometric design of the instrument significantly influences both the efficiency of bone debris removal and bone heating, as highlighted in work [4].

The duration of the osteotomy exerts a profound effect on cell survival. At 40, cell viability decreases after 7 minutes, whereas at 47, viability drops significantly within just one minute [4]. It is also critical to consider the time interval between drilling cycles, as bone can retain heat after the initial pass of a drill, and the immediate application of a subsequent drill will cause an even greater cumulative temperature rise [1].

Research by Hobkirk and Rusiniak demonstrated that a handpiece requires an average of 1.2 of force to prepare for an osteotomy [1]. In turn, Matthews and Hirsch established that the temperature at the handpiece-bone interface is more sensitive to the applied pressure than to the rotational speed of the drill [1]. Under a load of 1.2, cortical bone generated heat at 1800 Interestingly, when the rotational speed was increased to 2400 and the load was simultaneously increased to 2.4 kg, the heat level remained unchanged. However, the experiment demonstrated that increasing either pressure or speed independently of one another resulted in a temperature rise. Therefore, the selection of the optimal applied force depends directly on bone density.

To ensure efficient drilling, sufficient force must be applied to allow the drill to advance by at least 2 every 5 seconds. If the advancement rate is insufficient, the use of sharper or smaller-diameter drills is recommended for each preparation step. It is crucial to remember that excessive pressure on the drill can decrease its rotational frequency, which negatively affects cutting efficiency and induces overheating. To minimize this risk, preference should be given to surgical handpieces with high torque.

During osteotomy, the surgical template can significantly restrict, and sometimes completely prevent, the delivery of cooling irrigation solution directly into the drilling zone. The operation is performed through orifices located within narrow, closed channels that have minimal clearance. To guarantee the high accuracy of the navigation system, this clearance gap typically measures approximately 20, separating the sleeve fixed in the template from the removable keys/adapters [8].

To minimize the likelihood of bone tissue overheating during template-guided osteotomy, general recommendations advise reducing the rotational speed of the instrument, utilizing open-sleeve designs, ensuring supplementary irrigation, increasing the resting intervals between drill applications, and employing an intermittent drilling technique. These measures are validated by the research presented in works [2, 8–10].

Conclusion

An analysis of the existing literature indicates that osteotomy protocols in dentistry that do not involve the use of navigation guides are developed in a more detailed and evidence-based manner. Conversely, when navigation templates are utilized, current recommendations remain general and require further refinement and specification to establish a comprehensive protocol for minimally invasive jaw osteotomy. Further research in this domain is essential to facilitate the development of such specialized protocols.

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