TRANSCRESTAL SINUS FLOOR ELEVATION: A CRITICAL REVIEW OF MINIMALLY INVASIVE TECHNIQUES, INDICATIONS, AND LIMITATIONS

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Abstract. *Rehabilitation of the posterior maxilla is often complicated by alveolar ridge atrophy and sinus pneumatization, which reduce the available bone height for implant placement. Minimally invasive transcrestal sinus floor elevation has therefore become an important option for selected patients. This thesis critically summarizes current evidence on balloon-assisted elevation, hydraulic elevation, and osseodensification. Available studies indicate that these approaches may reduce surgical trauma and support simultaneous implant placement when anatomy is favorable. However, the evidence remains heterogeneous, and no method can be considered universally superior. The most reliable treatment planning still depends on residual bone height, sinus anatomy, membrane condition, cone beam computed tomography assessment, and surgical experience.*

Keywords: *sinus lift, transcrestal sinus floor elevation, minimally invasive surgery, balloon elevation, hydraulic sinus lift, osseodensification, dental implants.*

Introduction: Implant placement in the posterior maxilla remains one of the most demanding tasks in oral implantology. After tooth loss, alveolar

bone resorption and enlargement of the maxillary sinus frequently limit the vertical bone volume available for stable implant placement [1-3]. Sinus augmentation is therefore often required. Contemporary evidence shows that the transcrestal approach is most predictable in selected cases, especially when residual bone height is about four to five millimeters or more and when cone beam computed tomography confirms favorable sinus morphology [1,2].

Aim: The aim of this thesis was to critically assess minimally invasive transcrestal sinus floor elevation and to define the practical strengths and limits of balloon-assisted, hydraulic, and osseodensification techniques.

Materials and Methods: The paper was prepared as a narrative critical review. The analysis focused on contemporary reviews and representative clinical studies addressing minimally invasive transcrestal sinus floor elevation, including data on bone gain, implant stability, membrane perforation, and complications [1]. The selected publications were synthesized analytically rather than pooled statistically.

Results and Discussion: The conventional osteotome-mediated approach laid the foundation for transcrestal sinus floor elevation, but its limitations are well known. Malleting may increase patient discomfort, force transmission is difficult to standardize, and Schneiderian membrane injury depends strongly on anatomy and surgical skill [3,4]. Newer minimally invasive techniques were developed to achieve more controlled membrane elevation with less local trauma.

Balloon-assisted elevation seeks to reduce focal mechanical stress by gradual inflation beneath the membrane. This method is attractive in favorable anatomies because membrane lifting can be more controlled than with impact-based manipulation. Cadaveric and clinical studies have reported acceptable safety and implant outcomes, and a randomized clinical trial comparing the balloon technique with osseodensification showed that both methods may be effective during crestal sinus lift [5,6]. Still, the balloon approach should not be

interpreted as the automatic first choice because direct comparative evidence remains limited.

Hydraulic elevation follows a similar minimally invasive logic but uses fluid pressure to detach and raise the membrane more evenly. In a clinical study of hydraulic indirect sinus lift with simultaneous implant placement and platelet-rich fibrin, mean residual bone height increased from 5.57 plus or minus 0.66 millimeters to 9.72 plus or minus 0.43 millimeters, while implant stability quotient values improved from 69.07 to 72.92 after six months [7]. These results suggest clinically relevant bone gain, but the sample was small and protocol standardization remains incomplete.

Osseodensification differs from the previous methods because it combines transcrestal elevation with non-extractive bone compaction during osteotomy preparation. Its main advantage is the potential improvement of primary stability. A retrospective study reported Schneiderian membrane perforation in 4.8 percent of 144 interventions and mean vertical bone gain of 5.7 plus or minus 2.4 millimeters, with total height reaching 11.1 plus or minus 2.5 millimeters. These data are encouraging, yet baseline anatomy still remains decisive.

The central problem in this field is not the absence of positive results but the heterogeneity of the evidence. A recent systematic review on minimally invasive sinus augmentation analyzed 36 publications and 2732 procedures, but only two studies were randomized controlled trials and many non-randomized studies had serious risk of bias [4]. For this reason, no method can presently be declared unequivocally superior. Schneiderian membrane perforation remains the leading intraoperative complication, and the risk rises in the presence of sinus septa, unfavorable sinus floor morphology, variable membrane thickness, smoking, or insufficient radiographic planning [2,4]. From a practical standpoint, balloon-assisted elevation is useful when controlled membrane lifting is the priority, hydraulic methods are promising when reduction of focal

trauma is desired, and osseodensification is especially attractive when primary stability is critical. Nevertheless, residual bone height, sinus anatomy, and surgeon experience remain more important than the name of the instrument.

Conclusion: Minimally invasive transcrestal sinus floor elevation should be viewed as a selective clinical strategy rather than a universal substitute for conventional augmentation. Balloon-assisted, hydraulic, and osseodensification techniques all have plausible indications, but each requires careful radiographic planning and strict case selection. At present, the most defensible conclusion is that treatment choice should be based on anatomy, residual bone height, membrane condition, and operator experience, while categorical claims of superiority should be avoided until stronger comparative trials are available.

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