Journal of International Dental Sciences
Uluslararası Diş Hekimliği Bilimleri Dergisi

Derleme | Review

Minimal Invasive Approaches In Maxillary Sinus Lift Surgery: A Literature Review

Maksiller Sinüs Yükseltme Cerrahisinde Minimal İnvaziv Yaklaşımlar: Literatür Taraması

ABSTRACT

Objective: Sinus elevation surgery is performed to gain the vertical bone height necessary for implant placement in patients with insufficient residual maxillary alveolar bone. In this procedure, the sinus membrane is elevated and various graft materials are used to increase the bone volume in the posterior maxilla. Many approaches have been developed to elevate the sinus membrane from past to present. Both lateral and crestal approaches may be preferred in sinus lift surgery. The choice of technique should be supported by clinical and radiographic examination. The amount and quality of residual alveolar maxillary bone plays a very important role in determining which approach should be used. The lateral approach is recommended when the residual alveolar maxillary bone is less than 6 mm, while the crestal approach is preferred when the bone height is 6 mm or more. The crestal approach offers several advantages over the lateral approach, including less trauma, shorter surgical duration, lower risk of sinus membrane perforation, and reduced postoperative pain and swelling. Various internal sinus lift techniques have been described in the literature, including osteotomy technique, hydraulic pressure technique, balloon technique, osseodensification technique, and reamer approach. The advantages of the crestal approach have encouraged researchers to conduct additional research on this topic.

Conclusion: In this review, we will investigate current internal sinus lift techniques and present the results of comparative studies on various methods.

Key Words: Maxillary Sinus, Alveolar Bone, Implant.

ÖZ

Giriş: Sinüs yükseltme cerrahisi, rezidüel maksiller alveolar kemiğinde yetersizlik olan hastalarda implant yerleştirilmesi için gerekli dikey kemik yüksekliğinin kazanımı için yapılır. Bu prosedürde sinüs zarı yükseltilir ve posterior maksilladaki kemik hacminin arttırılması amacıyla çeşitli greft materyalleri kullanılır. Geçmişten günümüze sinüs zarını yükseltmek için birçok yaklaşım geliştirilmiştir. Sinüs lift cerrahisinde hem lateral hem de krestal yaklaşımlar tercih edilebilir. Teknik seçimi klinik ve radyografik inceleme ile desteklenmelidir. Rezidüel alveolar maksiller kemiğin miktarı ve kalitesi, hangi yaklaşımın uygulanması gerektiğinin belirlenmesinde çok önemli bir rol oynar. Rezidüel alveolar maksiller kemik 6 mm'den az olduğu koşullarda lateral yaklaşım önerilirken, krestal yaklaşım kemik yüksekliği 6 mm veya daha fazla olduğunda tercih edilir. Krestal yaklaşım, lateral yaklaşıma göre daha az travma, daha kısa ameliyat süresi, daha düşük sinüs membranı perforasyonu riski ve daha az ameliyat sonrası ağrı ve şişlik gibi çeşitli avantajlara sahiptir. Literatürde osteotom tekniği, hidrolik basınç tekniği, balon tekniği, osseodensifikasyon tekniği ve reamer yaklaşımı gibi çeşitli internal sinüs lift teknikleri tanımlanmıştır. Krestal yaklaşımın gösterdiği avantajlar, araştırmacıları bu konuya yönelik ek araştırmalar yapmaya teşvik etmiştir.

Sonuç: Bu derlemede, güncel internal sinüs lift tekniklerinin araştırılması ve farklı teknikler üzerine yapılmış karşılaştırmalı çalışmaların sonuçları sunulacaktır.

Anahtar Kelimeler: Maksiller Sinüs, Alveolar Kemik, İmplant.

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Geliş tarihi / *Received: 12.11.2024*
Kabul tarihi / *Accepted: 21.04.2025*

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INTRODUCTION

Following tooth extraction in the posterior maxilla, the rapid resorption of alveolar bone and pneumatization of the maxillary sinus make it challenging to place implants in the region. Therefore, it becomes crucial to perform a sinus lift procedure before implant placement to increase bone volume in the posterior maxilla. The sinus lift procedure aims to elevate the Schneiderian membrane and augment the bone volume in the posterior maxilla by placing a bone graft.

When deciding on sinus lift surgery, in addition to the patient's medical history and clinical examination, radiographic evaluation is also crucial. Due to the limitations of two-dimensional panoramic radiography, such as magnification, distortion, and superimposition, three-dimensional preoperative assessment has become essential to obtain information about the morphological characteristics of the sinus and residual bone (1, 2).

Due to the limitations of conventional computed tomography, such as high radiation dose, high costs, and the size of the equipment, cone beam computed tomography (CBCT) has become the standard for three-dimensional imaging. CBCT offers advantages such as higher resolution and lower radiation exposure compared to conventional CT (1, 2).

In addition to providing information about the height and width of the residual bone, CBCT can also offer details about the presence and diameter of the alveolar antral artery, irregularities in the sinus floor, the relationship of the Schneiderian membrane to the roots of adjacent teeth, the maxillary sinus septum, the quality of the subantral bone, and the volume estimation of the graft material required for sinus lift surgery (3).

The sinus lift procedure can be performed using the lateral (open) and crestal (closed) techniques. The lateral approach, initially described by Tatum in 1976, involves preparing a window in the lateral wall of the maxillary sinus, elevating the Schneiderian membrane, and placing bone graft material into the created space (4). This technique is used when the residual alveolar bone is less than 6 mm. When the residual height of the alveolar bone ranges from 3 to 6 mm, the simultaneous placement of an implant during the sinus lift procedure is called single-stage lateral antrostomy.

The single-stage lateral antrostomy eliminates the need for additional surgical procedures, shorter healing times, and reduced patient and clinician time. However, when the residual alveolar bone height is ≤ 4 mm, a two-stage lateral antrostomy is preferred, where the implant is placed 6-9 months after the sinus lift procedure to enhance implant stability following healing. This approach not only improves the efficacy of the surgical procedure but also provides a safer option for ensuring long-term implant stability (5, 6).

Although the lateral sinus lift procedure is a commonly used and more predictable approach, it can lead to several postoperative complications. These complications include Schneiderian membrane perforation, bleeding, implant migration into the sinus, sinusitis, damage to adjacent teeth, and ostium obstruction. Due to the lower risk of complications such as membrane perforation and bleeding, crestal approaches may be preferred over the lateral approach (7-9).

The crestal approach is less invasive than the lateral sinus lift technique, requires a smaller surgical area, and results in fewer postoperative complications. It also offers several advantages, such as reduced operation time, trauma, and postoperative morbidity. Researchers have described various techniques for crestal sinus lift, such as osteotome, balloon, and osseodensification (10, 11). The aim of this review is to investigate the clinical and radiological efficacy of minimally invasive crestal sinus lift methods.
(13).

Crestal Approach For The Sinus Lift

1. Osteotome Technique

The osteotome technique, introduced by Summers in 1994, involves sinus floor elevation and simultaneous grafting to enhance the primary stability of posterior maxilla implants. The primary goal of this technique is to preserve residual crestal bone to the maximum extent, which is crucial for achieving primary stability (12, 13).

This technique increases bone density to support primary stability and has the advantages of requiring less graft material and being less invasive. However, it has disadvantages, such as potentially low implant stability with less than 6 mm of residual bone, limited visibility, excessive force application, a higher risk of perforation, dizziness due to patient’s positional changes, and discomfort (11, 14).

In the osteotome technique, an incision is made at the top of the alveolar ridge, and a full-thickness flap is elavated. After the procedure, osteotomes are sequentially used to enlarge the implant socket. Each time a larger osteotome is placed, the bone becomes more condensed. Once the socket is sufficiently widened with osteotome which is suitable with the implant diameter, a controlled fracture is induced in the sinus floor when only a 1 mm bone layer remains. The osteotome is then employed to elevate the sinus floor, with the accumulated bone at its apical end aiding in lifting the sinus membrane. The graft material is then applied and the final osteotome

used is repositioned to secure its placement. After achieving the desired bone level, the implant is placed (11, 12, 15) (Figure 1).

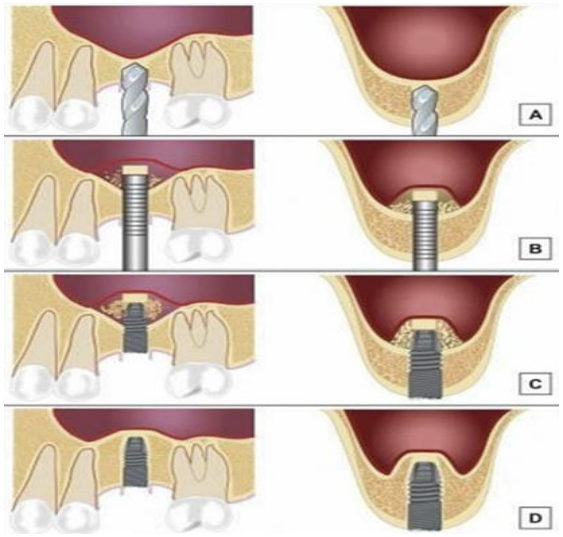

Figure 1. Osteotome technique (16).

2. Hydraulic Pressure Technique

In the hydraulic pressure technique, a device positioned beneath the sinus membrane directs hydraulic pressure—generated by a physiological saline solution—to lift the membrane. This technique reduces the risk of perforating the sinus membrane; however, complications from the potential loss of small fragments within the sinus can be more severe than other methods (17).

In this technique unlike the osteotome technique, crestal drilling is performed with diamond drills up to 1 mm into the maxillary sinus. At the end of this process, a 2 mm-diameter sinus bur is used to prepare an osteotomy site that tapers toward the apex at the sinus floor. To elevate the sinus membrane, physiological saline is slowly injected under pressure, facilitating the separation of the maxillary sinus membrane from the sinus floor. To maintain the position of the elevated sinus membrane, the graft material is then placed in the space (18, 19).

The hydraulic pressure technique can also be combined with piezoelectric surgery. The sinus floor is elevated under hydraulic pressure after the bone on the sinus floor is removed by piezoelectric surgery. The advantage of piezoelectric surgery is that it selectively targets hard tissue, reducing damage to the mucosa of the maxillary sinus (20, 21).

Li et al. concluded that piezoelectric osteotomy and hydraulic pressure application for sinus floor elevation for grafting and simultaneous implant placement may be an excellent alternative to traditional approaches (Summers' osteotome technique) due to less trauma and fewer complications (4) (Figure 2).

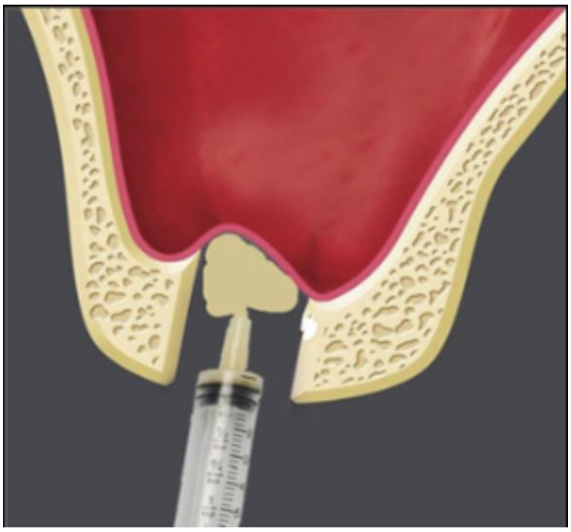

Figure 2. Hydraulic pressure technique (22).

3. Balloon Technique

In the Minimally Invasive Antral Membrane Balloon Elevation (MIAMBE) technique, the antral membrane is elevatörde from the osteotomy site using a specially designed balloon. The balloon method offers several advantages, including a reduced risk of perforation, an even force distribution at the membrane-bone interface, a lower complication risk, and a shorter operation time. However, its widespread use is limited by the need for specialized equipment (23).

In this technique, after elevated the full-thickness flap, osteotomy is initiated. The sinus floor is fractured after expanding the osteotomy site. After inspecting the sinus membrane, the balloon is placed and inflated under hydraulic pressure. When the desired elevation is achieved, the balloon is deflated and removed (24).

Elbareki et al. concluded that the balloon technique is a minimally invasive approach associated with minimal discomfort and few complications. The authors also found that the balloon technique can safely and reliably elevate the sinus floor supported by an implant. This method eliminates the need for graft material and promotes natural bone formation (25).

A study by Lopez-Quilez et al. concluded that the balloon technique for sinus lift is a safe, simple, and minimally invasive method that provides sufficient quantity and quality of bone for implant placement. Therefore, the balloon technique has become an option for clinicians to rehabilitate the posterior maxilla affected by atrophy (26) (Figure 3).

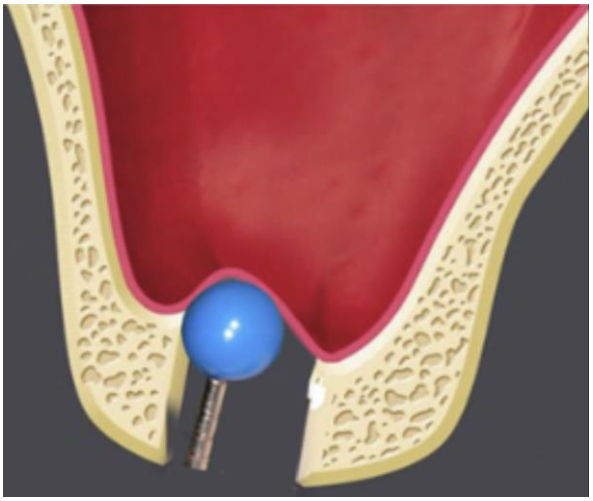

Figure 3. Balloon technique (27).

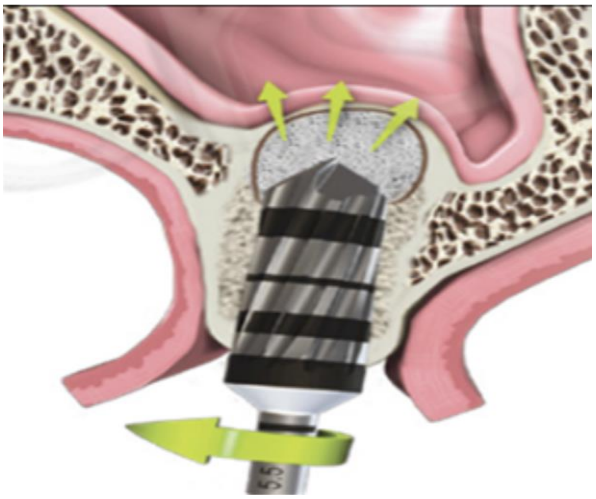

Figure 4. Osseodensification (31).

4. Osseodensıfıcation

The osseodensification technique, introduced by Huwais in 2013, is based on the principles of preserving and compacting the residual bone during sinus lift procedures. In this method, specially designed, progressively increasing diameter, counterclockwise rotating burs (Densah burs) are used. Due to their counterclockwise rotation, it is believed that bone compression occurs apically, thereby facilitating the elevation of the sinus membrane (28, 29).

When using osseodensification burs for lateral expansion of the alveolar bone, a flap is raised to ensure adequate visibility. Then, depth control is achieved with a pilot bur at a speed of 800-1500 rpm in a clockwise direction. The osteotomy procedure begins with the narrowest osseodensification bur in a condensing mode and continues until the planned dental implant diameter is reached. As the diameter of the bur increases, the alveolar bone is gradually expanded.

For vertical expansion of the alveolar bone using osseodensification burs, a flap is again raised to provide adequate visibility, and then marking is done with a pilot bur at a speed of 800-1500 rpm in a cutting mode, ensuring it remains 1 mm below the maxillary sinus floor. The bur sequence starts with a narrow-diameter osseodensification bur and is continued until the desired height of the maxillary sinus floor is achieved. This process continues in condensing mode until the desired bur diameter is reached (30).

Osseodensification burs are minimally invasive and eliminate the need for graft material placement. Osseodensification is applied when the need for sinus elevation is $\leq$ 3 mm and is a promising minimally invasive tool for the crestal sinus approach (29) (Figure 4).

5. Reamer Approach

In the reamer approach, specialised drills known as reamers, which only cut bone, are used as the osteotomy boundary to the sinus membrane. This treatment helps prevent trauma and perforations of the sinus membrane (32). Kim et al. concluded that the use of a new drilling technique (specially designed S-reamer) for the crestal approach in sinus lift procedures significantly reduced the risk of perforation and resulted in shorter operation times (33). In this approach, after raising the mucoperiosteal flap, entry is created using a round bur. Reamer drills with a stopper and non-cutting tips are used sequentially until a distance of 0.5-1 mm remains from the sinus floor. Reamer drills of varying lengths are used until the fracture of the sinus membrane wall is felt. Once the membrane wall is fractured, and a measurement tool is used to verify whether the membrane has been completely elevated. During the vertical elevation of the sinus floor, an osteotome or bone spreader is used to push the graft upward (34) (Figure 5).

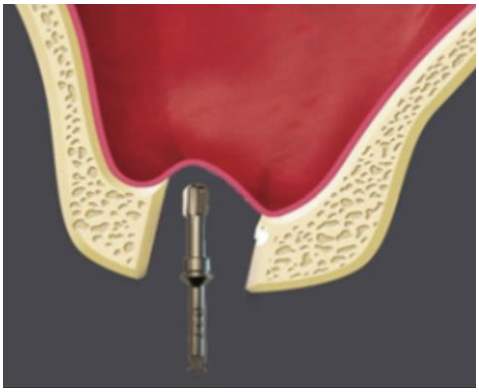

Figure 5. Reamer approach (35).

Maxillary sinus lift procedures help overcome challenges in placing implants in the posterior maxilla due to bone resorption and sinus pneumatisation. The amount and quality of residual bone are crucial factors in deciding the appropriate approach for sinus elevation (33). Every approach has its unique advantages and disadvantages. The crestal approach is less invasive than the open sinus lift technique, requiring a smaller surgical field and fewer postoperative complications. The crestal approach also offers several advantages, such as reduced operation time, less trauma, and lower postoperative morbidity (11).

Attar et al. suggested that the osteotome sinus lift technique in the posterior maxilla is a non-invasive and predictable procedure that allows for implant placement and recommends that the residual bone height should be greater than 5 mm for optimal results with this technique (36).

The bone graft material is used to preserve the volume of the sinus membrane following the sinus lift procedure. However, avoiding the use of grafts can reduce the risk of infection, shorten the surgical time, and decrease the cost (37-39). Şenyılmaz et al. evaluated the 2-year clinical and radiographic outcomes of implants placed without graft material using the osteotomy technique in sinus lift surgery, obtaining a survival rate of 100 % (40). In a study by Manekar et al., which evaluated the clinical and radiological success of crestal hydraulic sinus elevation and simultaneous implant placement without grafts, the average subantral bone gain was 5.6 mm, and the survival rate of all implants was 100 % (41).

While less invasive than the lateral approach, the osteotome technique has limitations, such as a high risk of sinus membrane perforation, excessive force application, and potential patient discomfort. These limitations have led to the exploration of various minimally invasive techniques (42).

In a study by Ahmed et al., it was found that computer-guided simultaneous implant placement with the osseodensification technique had a significantly shorter procedure time compared to sinus lift via the lateral approach. Additionally, the osseodensification technique demonstrated a significant increase in bone density both immediately after surgery and at the 6-month follow-up, whereas a significant decrease in bone density was observed in the lateral approach group (43).

A study by Shende et al. compared crestal approaches, including hydraulic lift (CAS Kit) and osteotome techniques, and found that the implant placement time was an average of 13.40 ± 2.98 minutes for the hydraulic lift group and 22.10 ± 2.55 minutes for the osteotome group. The average primary stability was 44 ± 6.14 NCM for the hydraulic lift group and 35.50 ± 7.61 NCM for the osteotome group. Furthermore, at three months, the average radiographic bone regeneration was 4.99 ± 0.86 mm in the hydraulic lift group and 5.59 ± 1.21 mm in the osteotome group. At nine months, the average radiographic bone regeneration was 5.53 ± 0.77 mm in the hydraulic lift group and 6.34 ± 1.11 mm in the osteotome group (44).

In a study by Madab et al., comparing the hydraulic sinus lift and osteotomy techniques, no significant difference was found between the two techniques in terms of subantral bone height. However, the hydraulic lift technique demonstrated a lower perforation rate compared to the osteotomy technique (45).

The hydraulic pressure technique can be combined with piezoelectric surgery, which is selective for hard tissue and minimises sinus mucosa damage. Li et al. concluded that piezoelectric osteotomy and hydraulic pressure application for sinus floor elevation, with less trauma and fewer complications, could be an excellent alternative to traditional approaches (e.g., Summers' osteotome technique) (4).

In a study by Alajami et al., comparing the antral membrane balloon technique with the osseodensification technique using Densah drills, the residual bone height in the balloon technique group was found to be 8.31 ± 0.44 mm immediately after sinus lift and 6.02 ± 0.85 mm six months post-surgery. In comparison, the osseodensification technique group had residual bone heights of 6.75 ± 1.13 mm immediately after surgery and 5.63 ± 1.03 mm at six months. The results indicated that the balloon technique showed better results for vertical bone height and gain immediately after surgery. In contrast, the osseodensification technique provided better primary implant stability, less reduction in vertical bone height, and more significant increases in bone density (46).

Arafat et al., in their study comparing osteotomy and osseodensification techniques, found that at 6 months, bone gain in the osteotomy group was 2.79±0.30 mm, while in the osseodensification group it was 3.33±0.25 mm. They concluded that the osseodensification technique resulted in greater bone gain compared to the osteotomy technique (47).

However, in their 2023 study, Hashem and colleagues compared osseodensification techniques using piezosurgery, osteotomy, and Densah burs. They found that the osteotomy technique resulted in greater vertical bone gain compared to the other methods. Additionally, when implant stability was evaluated, the highest stability was observed with the osseodensification technique utilizing Densah burs (48). The differences in vertical bone gain may be related to the small sample sizes and short follow-up periods in this study. Therefore, larger sample sizes and longer follow-up studies are necessary.

Endoscopy has been used for years to diagnose and treat maxillary sinus diseases. During maxillary sinus lift procedures, endoscopy allows direct visualisation of the sinus membrane, which can help detect and manage membrane perforations. However, more studies are needed to evaluate whether these benefits outweigh the disadvantages, such as equipment requirements, sometimes the need for a second operator, and high costs (49, 50).

CONCLUSION

In atrophic posterior maxilla and sinus pneumatisation cases, sinus lift procedures are essential for implant placement. The sinus lift can be performed using a lateral or a crestal approach. The crestal approach has several advantages over the lateral approach, including its being less invasive, requiring a smaller surgical field, resulting in fewer postoperative complications, shorter operation time, and causing less trauma and postoperative morbidity. Although the crestal approach, precisely the osteotome technique, offers these advantages, it is associated with a higher risk of sinus membrane perforation and potential patient discomfort. These factors have prompted researchers to explore minimally invasive crestal approaches for sinus lift procedures. Minimally invasive crestal sinus lift techniques, such as hydraulic, osseodensification, and the balloon technique, provide clinical and radiological results similar to those of the osteotome technique. They appear to have a low risk of membrane perforation and provide high patient comfort. The number of studies assessing the effectiveness of current minimally invasive sinus lift techniques is limited, indicating a need for further research involving long-term comparisons. In the sinus lift procedure, the use of graft material facilitates the placement of implants by providing sufficient bone volume. However, success can also be achieved without the use of graft material. There are studies in the literature showing that implants placed with or without graft material have similar survival rates.

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