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RESEARCH ARTICLE

BENIGN PAROXYSMAL POSITIONAL VERTIGO (BPPV) FOLLOWING MAXILLOFACIAL PROCEDURES AND TRAUMA: A RARE BUT REAL COMPLICATION – REVIEW AND CASE REPORT

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Abstract

The most common type of peripheral vertigo, benign paroxysmal positional vertigo (BPPV), is caused by dislodging otoconia (calcium carbonate crystals) into the inner ear's semicircular canals, which lead to transient episodes of vertigo with positional head movements. Otolaryngology and neurology clinics regularly experience BPPV, but oral and maxillofacial surgery are increasingly diagnosing it, particularly after percussive instruments, vibrational forces, or major cranial manipulations .Indirect sinus lifts with osteotomes and surgical mallets have been associated with BPPV . New evidence, though, links ridge augmentation, TMJ surgery, Densah bur mandibular implant placements, and facial trauma reconstruction with BPPV. Osteotomy mechanical stress, over-tapping, and neck hyperextension may induce BPPV through the vibration of the vestibular system .BPPV mechanical mechanism, clinical diagnosis, and oral and maxillofacial treatment are discussed in this comprehensive study. Two case reports consist of a peculiar BPPV case after flapless mandibular implant placement with the use of osseodensification burs, a low-trauma procedure. Early identification, appropriate diagnosis, interdisciplinary referral, and surgical prevention are emphasized. Awareness can be beneficial in enhancing maxillofacial surgical patient safety, medico-legal risks, and recovery.

Introduction:-

Benign Paroxysmal Positional Vertigo (BPPV) is a mechanical inner ear disorder that leads to transient dizziness, unbalance, or a feeling of spinning with changes in head position at a rapid pace. Otoconia—tiny calcium carbonate particles—from the utricle into the semicircular canals, normally the posterior canal, is primarily the cause. They disrupt endolymphatic fluid flow and activate the vestibular system, triggering the vertigo [1][2].
Lifetime incidence of BPPV is 2.4% and represents 20–30% of clinical vertigo [3]. It occurs more frequently in women and elderly people. It's largely idiopathic, but 30–40% are secondary, resulting from head injury, inner ear infection, vestibular neuritis, or iatrogenic reasons [4].

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In oral and dental surgery, iatrogenic BPPV remains underdiagnosed despite an increasing case series. Osteotome sinus elevation can lead to abrupt onset BPPV by physically vibrating the craniofacial skeleton and freeing the otoconia [5][6]. However Indirect Sinus Lift using Densah burs, a rotary osseodensification device, has reduced the chances of BPPV associated with osteotome sinus elevation in Maxilla.
Chisels, incorrect placement of patients during surgery (i.e., neck hyperextension), and magnet mallets can all exacerbate otoconial movement. If patients complain of dizziness and/or imbalance postoperatively, oral and maxillofacial surgeons are obligated to investigate BPPV.

This Comprehensive Article Addresses:

- Maxillofacial surgeries related to BPPV
- Otoconial displacement pathophysiology
- Case histories, including a mandibular implant-associated BPPV
- Diagnostic approaches: Dix-Hallpike maneuver
- Management: Canalith repositioning maneuver
- Preventive techniques and clinical guidelines
- Clinicians can minimize morbidity and improve patient outcomes following maxillofacial interventions by increasing awareness and early identification of this complication.

Maxillofacial Procedures Linked To Bppv.

Benign Paroxysmal Positional Vertigo (BPPV) is classically linked with otologic or neurologic disease, but increasingly it appears to occur after craniofacial surgery. Mechanical stress or pressure on the vestibular system causes otoconia to be displaced into the semicircular canals. A number of routine oral and maxillofacial procedures could be the causes:

I. Osteotome-Indirect Maxillary Sinus Lift -Graded osteotomes and a mallet are used in the osteotome sinus lift procedure to percuss the floor of the sinus, one of the earliest dental causes of BPPV. Repeated percussive stresses can lead to otoconial displacement and vertigo by vibrating the maxilla and vestibular system [7][8]. Newer rotational method like Densah Burs has significantly reduced the chances of BPPV in Indirect Sinus lift cases in Maxilla[9].

II. Ridge Expansion with Osteotomes or Mallets -Ridge splitting or expansion, such as sinus lifts, employs chisels or osteotomes in thin ridges. Microvibrations resulting from posterior maxilla or mandible malleting, particularly in the case of dense cortical bone, can cause BPPV [10].

III. Densah Bur (Osseodensification) in Osteotomies -Densah burs, as a low-trauma percutor alternative to drilling, however reduced the chances of BPPV associated with osteotome, can produce severe haptic feedback and bone-compacting vibration while preparing the osteotomies specially if used in the compact Medullary bone like Mandible . These forces can be transmitted all the way down to the cranial base and can move otoliths in patients with dense bone in the medullary canals and narrow ridge walls [11]. New Finding: We present the first case of BPPV after flapless mandibular implant placement with Densah burs, a low-risk site.

IV. Third Molar Surgery Using Chisel and Mallet- Extraction of impacted third molars, particularly in the mandible, often requires the use of chisels and surgical mallets for bone guttering or elevation. These instruments generate significant percussive forces that may propagate vibrations through the skull base, potentially dislodging otoconia in susceptible individuals. While neck hyperextension during lower third molar surgery may act as an additive factor, the primary mechanism remains mechanical vibration from instrument use. Due to underreporting and low awareness, BPPV after third molar surgery may be misattributed to anesthetic effects or postural instability [12].

V. Midfacial trauma and orthognathic operations -Maxillary or zygomatic relocation and midfacial fracture operations can inadvertently shock the vestibular apparatus-containing temporal bone. Vestibular postoperative symptoms should be evaluated in the subject with Le Fort osteotomies and patients with trauma [13][14].

VI. Too Much Neck Extension and TMJ Surgery During Procedure -TMJ surgeries or operations that involve long neck hyperextension, e.g., supine dental postures, could induce BPPV by displacing dislodged otoconia in the canals [15].

VII. Blurry Maxillofacial Trauma -Non-surgical injury such as road traffic accidents or facial injury as a result of sport may tear or vibrate otoconia. Post-traumatic BPPV can be confused with post-concussion dizziness or postural instability [16]. Clinical Gems: Post surgical BPPV can be mistakenly diagnosed as dehydration, anxiety, or anesthesia. Patients with vertigo should be reviewed by an ENT during the first 24–48 hours after surgery.

Etiology.

The underlying mechanism of BPPV involves the displacement of otoconia from the utricle into the semicircular canals of the inner ear. Under normal conditions, otoconia help detect linear acceleration. When dislodged, they can settle into the posterior semicircular canal and move in response to gravity, causing inappropriate endolymph flow and misleading signals to the brain about head motion [8]. Most BPPV cases are idiopathic, particularly in older adults. However, up to 30% are classified as secondary BPPV, with known precipitating factors such as head trauma, vestibular neuritis, migraine, Meniere's disease, and otologic surgeries [9]. Historically, iatrogenic BPPV has been observed predominantly in dental implantology, especially following sinus lift procedures involving osteotomes and surgical mallets. The percussive impact and craniofacial vibration generated by these instruments were known to transmit mechanical stress to the vestibular system, thereby dislodging otoliths [10][11].

In recent years, the introduction of Densah burs and osseodensification techniques has significantly reduced this risk in maxillary sinus lifts. Densah burs operate in a counterclockwise, non-cutting mode, compacting bone instead of removing it, and are considered less traumatic. Because maxillary bone is relatively less dense, the force transmission to the vestibular system is minimized, thus lowering the risk of BPPV [11].

However, our report of a mandibular implant case with Densah burs challenges the assumption of complete safety. The mandible's denser medullary bone may transmit stronger vibrational or haptic forces during osseodensification, sufficient to disturb the otoconial matrix even without sinus involvement or mallet use. This case underscores that while Densah burs reduce BPPV risk, especially in maxillary applications, mandibular sites with dense bone remain susceptible.

Additional surgical variables such as patient head hyperextension, duration of surgery, and total vibratory input may further increase the risk. Patients with a history of vertigo or vestibular dysfunction may be more vulnerable, but this complication can also occur in previously healthy individuals with no prior complaints [4][6].

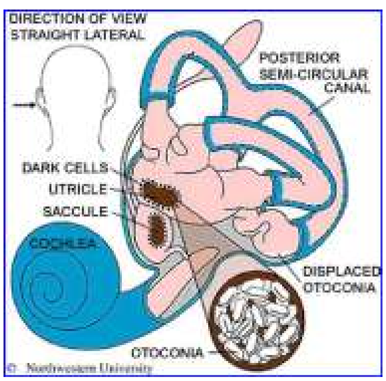


Figure 2 Inner Ear Anatomy Showing Otoconia Dislodgement (utricle → posterior semicircular canal

Pathophysiology Of Bppv In Maxillofacial Surgeries.

BPPV results from the mechanical disruption of the vestibular system, i.e., the displacement of otoconia—tiny calcium carbonate crystals—in the utricular macula of the inner ear. Physiologically, the otoconia adhere to the gelatinous membrane and sense gravity and linear acceleration. Because the otoconia have a dependent anatomical position when the patient reclines, they may become dislodged and move into one of the semicircular canals, typically the posterior canal, as a result of maxillofacial surgeries [17]. Displaced otoconia interrupt endolymph flow in the semicircular canals when the head rotates. Canaliths tilt the cupula, stimulating ampullary crest hair cells with their anomalous drag. Disturbances in the labyrinth's input lead the brain astray and produce vertigo, unbalance, and nausea [18]. Attacks are ordinarily transient, positional, and reproducible by reclining back, rolling in the bed, or looking up.

Two theories explain the mechanism of BPPV's. Most popular is Epley's 1980 theory of canalithiasis. According to it, broken-down otoconia are free-floating in the semicircular canal and produce transient endolymphatic currents with head movements. Vestibular hair cells are activated by such currents and produce transient vertigo and nystagmus [19]. According to Schuknecht's theory of cupulolithiasis in 1969, dislodged otoconia become stuck on the cupula. Owing to the cupula's sensitivity to the direction of gravity, deflection and vertigo are more sustained [20].A few methods can mobilize otoconia during maxillofacial surgery. Sinus lift procedures with osteotomes and mallets repeatedly vibrate the craniofacial bones mechanically, potentially impacting the inner ear. Even during less traumatic implant osteotomy with Densah burs, compaction drilling generates haptic input and pressure waves, especially in comparatively denser medullary bone. This pressure, though less traumatic than mallet impacts, can disturb the sensitive otoconial matrix, particularly in susceptible individuals [21].

Additionally, supine or reclining posture for oral operations can lead to gravitational otoconial migration. Hyperextension at the neck, common in the extraction of mandibular third molars and procedures on the temporomandibular joint, repositions the alignment of the semicircular canals, permitting free otoconia migration into the posterior canal [22]. Blunt facial injury, e.g., zygomatic fracture, road traffic accidents, vibrates the labyrinthine system and gives rise to secondary or post-traumatic BPPV [23]. Symptoms of BPPV tend to occur hours or days after the procedure. Surgical fatigue, worry, or anesthesia effects may delay the diagnosis or lead it being overlooked. Oral and maxillofacial surgeons should thus have a heightened degree of suspicion if patients present with postoperative vertigo, dizziness, or unsteadiness when no systemic cause exists.

Preexisting vestibular disorders, migraines, or vertigo are risk-increasing and would need preoperation assessment. In addition, cumulative damage with bilateral operations, multiple sites of implantation, or more lengthy operations could augment susceptibility [24]. BPPV in craniofacial settings is brought on by otoconial dislodgement, procedure vibration, patient posture, and anatomical predisposition. Identifying the mechanism makes it easier to diagnose, refer, and prevent.

Case Report:

BPPV Following Flapless Mandibular Implant Placement Using Densah Burs – A Novel Complication

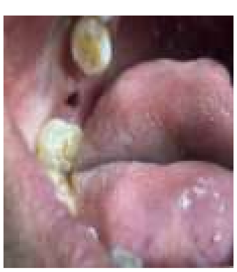
A 49-year-old male patient visited the Department of Oral and Maxillofacial Surgery at Rajasthan Dental College and Hospital, Jaipur, for replacement of a missing mandibular right first molar. The ridge width was found to be narrow approx. 4mm, but bone density was moderate.

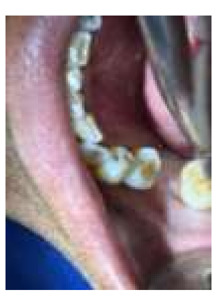
A flapless implant placement was planned using osseodensification (OD) technique with Densah burs (Versah®, USA). The osteotomy was performed in counter-clockwise, non-cutting mode to laterally compact the bone, achieving ridge expansion and enhanced primary stability. No mallet, chisel, or osteotome was used. However, the procedure involved moderate haptic feedback, and minor jerky vibrations were observed during apical drilling due to bone resistance.

The patient was in a supine position during surgery. Approximately six hours postoperatively, while getting up from bed to use the restroom, he experienced a sudden onset of vertigo, imbalance, and nausea. He was unable to walk without support and felt a spinning sensation while turning his head. He was taken to an emergency unit and an ENT evaluation was initiated. The Dix-Hallpike maneuver elicited a strong torsional upbeat nystagmus, and posterior canal BPPV was diagnosed. The patient had no previous history of vertigo or neurological disease. Two Epley maneuvers were performed over the next 48 hours, resulting in complete symptom resolution. The implant site healed uneventfully.

This case is the first to report BPPV as a complication of mandibular implant placement using Densah burs without any sinus manipulation or use of mallets. It highlights that osseodensification, although marketed as low-trauma, may produce localized percussive vibrations sufficient to displace otoconia in predisposed individuals [27].

This case expands the scope of BPPV risk beyond sinus lifts, showing that even mandibular procedures—especially involving dense bone and OD—must be approached cautiously. Radiographic evidenceand intraoperative photos of the procedure are available and may be submitted with this article.





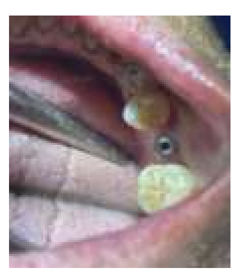


Figure 3. Radiographic and clinical documentation of flapless mandibular implant placement using Densah burs: (A–D) Pre-operative &Intraoperative radiographs of the case(E-G) Intraoral views confirming implant position and healing. These images correspond to the case of BPPV onset following mandibular implant surgery and highlight the absence of sinus involvement and mallet use.

Diagnosis Of Bppv In Maxillofacial Surgery Patients.

Benign Paroxysmal Positional Vertigo (BPPV) imitates postoperative issues such as hypotension, anxiety, and anesthetic response, so it must be accurately diagnosed when maxillofacial surgery takes place. Your patient experiencing sudden vertigo or dizziness after the use of chisels, osteotomes, surgical mallets, or osseodensification burs should be treated with utmost clinical suspicion [28].

BPPV presents as sudden, transient episodes of vertigo precipitated by changes in head position, often related to rising from bed, bending forward, or head turning. Patients complain of falling, unbalance, nausea, or they say they are spinning. It can occur hours or days postoperatively, particularly after maxillary sinus lifts, extraction of a third molar, TMJ surgeries, blunt impact, or vibrational instrumentation injury repair [29].

BPPV is clinically confirmed by using vestibular positional tests. Dix-Hallpike maneuver is the optimal test for diagnosing posterior canal BPPV, the most common damage in the semicircular canals. Patient is rapidly shifted from a seated position into the supine position with the head rotated 45 degrees toward the test direction and 20 degrees backward. Inducing vertigo and the torsional, upbeat nystagmus after a short latent interval are positive test results. Time fatigues the response, validating the diagnosis [30].

Horizontal canal patients: If the vertigo results from rolling over in bed or supine head rotation, the Supine Roll Test will be employed to raise the suspicion for BPPV. In the Supine Roll Test, the patient reclines supine with the head rapidly rotated into each direction. Horizontal nystagogy occurs with geotropic and apogeotropic nystagmus locating the canal [31].

When patients present with dizziness after the operation, ENT specialists should be referred early since oral and maxillofacial surgeons will not perform vestibular tests. Advanced positional testing, VideoNystagmoGraphy (VNG) is an advanced approach to diagnose the displacement of otoconia in particular canal. Ménière’s disease, vestibular neuritis, and central vertigo could be eliminated with ENT consultation [32].

Significantly, some patients might have occult vestibular impairment. People experiencing vertigo, dizziness with migraine, or head injury are some examples. Otoconia dislodgement can be caused by minor vibratory stimuli on mandibular implant placement or TMJ manipulation in such patients [33].

As per literature and our clinical case, patients who are being treated with mallets, Densah burs, chisels, or osteotomes, head hyperextension, or maxillofacial trauma must be carefully observed for vertigo. Diagnostic watchfulness ensures early diagnosis, proper treatment, and prevention of unnecessary imaging.

Management Of Bppv In Maxillofacial Surgical Context:

BPPV in post-maxillofacial surgical patients can adversely affect recovery, daily function, and surgical outcome, and thus treatment should be early, exact, and minimal. BPPV treats well with conservative management if diagnosed early, precluding use of medications or surgical intervention in the majority of patients.

Epley maneuver, a set of head and body position changes to relocate dislodged otoconia into the utricle, away from the posterior semicircular canals, where they will be unable to create aberrant endolymphatic flow, is the ideal treatment for posterior canal benign paroxysmal positional vertigo. Beginning with the patient in the sitting position with the head 45 degrees over the affected side, the maneuver begins. The patient is rapidly taken supine with head extension for a 30-second hold. The head must be rolled over into the opposite direction and the body rotated after which the patient will be placed in the position of being seated. This maneuver's success rate is achieved with one session by a rate of 70–90%, and recurrence can be minimized after performing multiple sessions [34][35].

In our Case Report, two successive Epley maneuvers fully alleviated your symptoms, validating that this technique holds even in iatrogenic BPPV cases alongside innovative surgical methods such as mandible osseodensification.

Barbecue Roll or Gufoni procedure are employed for the purpose of treating horizontal canal BPPV, which is uncommon but can happen in post-traumatic or surgical patients. Canaliths within the horizontal semicircular canal relocate to a neutral position with lateral head rolling or lying on the sides [36].

Treatment of BPPV is restricted by medications. Vestibular suppressants like meclizine, promethazine, and betahistine can ease acute nausea or anxiety temporarily but failed to correct positional disruption. Avoid long-term use of vestibular suppressors as it might inhibit central compensation and recovery [37].

Surgery is limited and reserved for the treatment of long-standing or recurring BPPV that resists multiple repositioning maneuvers. While posterior canal occlusion and isolated neurectomy are possibilities, they carry the risk of sensorineural hearing loss and are not generally recommended, particularly in iatrogenic oral surgical procedures [38]. Barbecue Roll &Gufoni Maneuver: These maneuvers are indicated for horizontal canal BPPV, using sequential head rotations in the supine position to move the canaliths [28].

Figure5 Diagram – Epley Maneuver Step-by-Step Illustration

ENT referral is necessary in a timely manner by maxillofacial surgeons. Effective communication with otolaryngology results in early repositioning, reduces patient distress, and avoids surgical complications and implant failure misdiagnosis. In all, successful and conservative BPPV treatment after maxillofacial operations are routine. Early detection, referral, and education of the patient regarding temporary vertigo issues after facial modification are essential.

Epidemiology Of Bppv In General And Maxillofacial Practice.

Most peripheral vertigo in the population is caused by Benign Paroxysmal Positional Vertigo (BPPV). Based on epidemiological evidence, lifetime prevalence equates to 2.4% and annual incidence varies between 10.7 and 64 per 100,000, based on age and geography [39]. In dentistry and maxillofacial practice, BPPV is more frequently underdiagnosed than it would be expected based on the frequency.

Women are twice more likely than men to have BPPV. This could be caused by hormonal influences on the metabolism of calcium and the stability of the otoliths [40]. With age-associated damage to the otolithic membranes in the inner ear, incidence rises between the fifth and seventh decades [41].

Most instances of BPPV are idiopathic, notably in the elderly. A total of as much as 40% of the instances of BPPV are secondary, resulting from head trauma, vestibular neuritis, or iatrogenic therapy [42]. Surgical and dental iatrogenic BPPV resulting from treatment is increasingly being recognized but not documented sufficiently in the oral and maxillofacial literature.

Symptoms often appear late, a few hours or days postoperatively, and might be mistakenly ascribed to anesthetic effects or systemic pathology. Oral and maxillofacial surgeons might be unaware of the signs of BPPV or will not recommend patients for vestibular testing.

This case emphasizes the necessity for awareness of BPPV extending over various maxillofacial surgical procedure from sinus lift to, as exhibited by the case with the unusual mandibular implant. Specialists in oral surgery and implantology need to understand iatrogenic BPPV with the development of osseodensification, the use of magnet mallets, and flapless implants [43]. BPPV ranks among the most treatable causes of vertigo, but non-ENT specialists' unawareness causes it to go unreported, the care being delayed and the patient suffering unnecessarily. Raise the index of suspicion for high-risk maxillofacial surgeries first in an effort to close the gap in this diagnosis.

Preventive Strategies For Maxillofacial Surgeons.

Prevention of BPPV in maxillofacial surgery involves screening preoperatively, making intraoperative adjustments, and being watchful postoperatively. BPPV is unpredictable, but planned foresight and technique adjustment may minimize its incidence among susceptible craniofacial patients.

Preoperational risk assessment forms the foundation of prevention. In a full clinical history, inquire about vertigo, dizziness, balance issues, migraines, and vestibular disease. Otoconial changes are degenerative changes that increase the risk for elderly and female patients in idiopathic BPPV [44]. A past history of "dizziness when rising rapidly" or a "feeling lightheaded when rolling over in bed" can be a sign of latent BPPV that will become symptomatic in the postoperative setting.

Surgical Technique Procedures that induce vibrational or percussive forces around the skull base demand adjustments. In the use of osteotomes, surgical chisels, mallets, or Densah burs in the procedure for osseodensification, be cautious. Avoid over- and repetitive malleting. Motorized drills with progressive, controlled torque minimize cranial transmission of force. Although flapless and minimally invasive techniques might lower stress, they still produce haptic feedback forces with denser bone, potentially displacing otoconia in people with a history of vertigo [45].

Optimize head intraoperative positioning. Altered fluid mechanics in the vestibule, induced by increased and sustained neck extension during maxillary sinus elevation, third molar extraction, or the reduction of a zygomatic fracture, can raise the risk of otoconial migration [46]. Prevent pressure against the posterior semicircular canal by positioning the patient in a neutral or mildly stretched head and relocating it periodically with long-standing operations.

Monitoring and patient instruction in the postoperative setting are often undervalued but are essential for early discovery. Patients must refrain from making abrupt head movements during the first 24–48 hours postoperatively. They must be instructed to report immediately if they have a spin, unbalance, or nausea. Because the manifestations often occur hours after discharge, patient education early on can expedite the diagnosis and treatment [47].

Early diagnosis not only prevents unnecessary investigations but also enables prompt non-invasive treatment using repositioning maneuvers. In some cases, patients may first present to their dentist or surgeon, highlighting the need for interdisciplinary communication with ENT specialists.

Figure4 Demonstration of Dix-Hallpike Maneuver – Sequence of Positions and Expected Nystagmus

ENT collaboration should not be delayed. Surgeons should have suspicious patients referred early to regional otolaryngologists. Dix-Hallpike test and Supine Roll test are early interventions in this inter-professional model, as repositioning maneuvers can be done early [48].

Surgeons need also to appreciate that even minor, repetitive mechanical stimuli to the jaw may trigger BPPV with emerging surgical tools such as magnet mallet devices or Densah burs that necessitate vibratory input. Preventive strategy, accordingly, involves equipment selection, regulation of torque, and surgical planning.

With diligent taking of a patient's history, operational adjustments, and vigorous patient counseling, oral and maxillofacial surgeons can significantly reduce the incidence and impact of this unrecognized yet curable complication.

Conclusion.

BPPV has traditionally been a field of otolaryngology and neurology, but clinical findings now demand its identification in maxillofacial and oral surgery. Previously a seldom encountered complication of sinus lift surgeries, today the BPPV stands as a legitimate and still underdiagnosed complication of a more extensive diversity of maxillofacial procedures, including osteotome- and Densah bur-supported implant placement, orthognathic surgeries, extraction of impacted third molars, TMJ, and traumatic manipulations close to the cranial base [49][50].

BPPV—otoconia dislodgement by vibratory or percussive pressure—is particularly pertinent in bone tapping, bone compaction, or sudden craniofacial injury [51]. A first-in-man case in this review demonstrates flapless implant placement with mandible osseodensification transferring haptic loads great enough to produce vestibular perturbation [52].

BPPV is diagnosed readily by clinical history, symptoms, and positive Dix-Hallpike or Supine Roll tests. In more than 90% of posterior canal cases, non-invasive canalith repositioning procedure such as the Epley technique [49] is successfully treated. Dental or surgical specialists' unawareness often causes delay in making a diagnosis with resulting prolongation of patient discomfort, impaired recovery, and diminishing surgical success [50].

With the use of percussive instruments such as osteotomes, chisels, mallets, and Densah burs, BPPV is a hazard in a wide variety of maxillofacial surgeries, not only sinus lifts [51]. It emphasizes blunt craniofacial injury and axial neck hyperextension as causatives. It advocates a fresh alertness and inter-specialty coordination among maxillofacial surgeons and ENT specialists in addition to sinus lifts [50][52].

Prevention in the form of awareness, preoperation screening, and enhanced surgical procedure can significantly avoid this complication. Patients must be cautioned by surgeons regarding transient vertigo issues, particularly in susceptible anatomical regions with vestibular preponderance [49]. Early treatment and detection are critical in the uncommon instances of BPPV [49][52].

Lastly, despite how benign and reversible it is, BPPV demands significant consideration in contemporary maxillofacial treatment. By being aware of it occurring outside the sinus, physicians can enhance patient care and foster a more well-informed, proactive, and preventative surgical culture [50][51].

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