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The Percrestal Sinuslift – From Illusion to Reality

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Preface

Minimally invasive surgical techniques are being increasingly used throughout medicine, often replacing conventional surgery. In many instances conventional techniques cannot match the outcome obtained with them. As a rule, this is due to the use of more or less subtle endoscopic procedures and innovative radiologic techniques. The many abdominal procedures and invasive radiologic interventions for cardiovascular conditions are apt examples. These sophisticated procedures have revolutionized many medical specialties. Their reliable outcomes and efficiency have been fundamental to their acceptance. Still, the mastery of traditional surgical skills and conventional techniques is indispensable, because minimally invasive techniques are, at times, contraindicated for whatever reasons or may fail.

Turning to minimal invasiveness in implant dentistry and bone grafting has been a logical consequence of these developments. The introduction of incision-free dental implant placement based on computer-assisted planning impressively documents the progress made. Similar innovations in bone grafting are less impressive. Transcrestal sinus floor elevation, introduced by Summers in 1994, is an exception, and its increasing popularity is reflected by the growing number of reports on the subject (Fig 1).

However, a closer look at all these reports casts doubt on the efficiency and predictable success of transcrestal sinus floor elevation. The technique is almost exclusively advocated at a vertical bone volume at which adequate implant stability can also be expected without augmentation, at least for a limited period of time. If less bone is available, the failure rate, as a rule, rises to levels which would rule out the use of the method by general medical standards. According to the most recent reports, preoperative diagnosis and planning as well as postoperative follow-up are hardly ever compatible with the currently established medical options offered by radiology. Basic microanatomy and microbiology are often neglected and the potential involvement of the entire sinus pre- and postoperatively is ignored.

This book is not intended to provide a set of universally applicable principles for all procedures. This would, in fact, be presumptuous. But it is intended to alert the reader to the shortcomings of the various techniques, with the intention of providing a blueprint that may serve as a guide – albeit one that will surely need improving in one or another aspect in the future. This is the only way to develop transcrestal sinus floor elevation into a surgical technique that meets the general medical standards of a minimally invasive procedure.

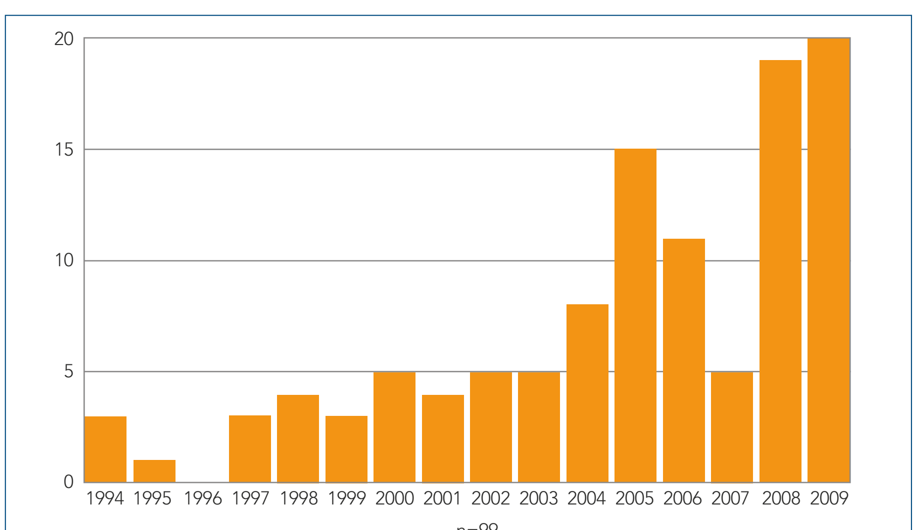

Fig 1 Number of publications on transcrestal sinus floor elevation as per PubMed.

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I would like to pay tribute to all of them:

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Last, but not least, I would like to present my heartfelt thanks to Quintessence Publishing for unhesitatingly accepting the project for publication, and their staff for their traditionally untiring assistance and patience.

Contents

4.1 Introduction

A look at the available literature shows that most methods that have been described are based on small sample sizes, presented as diagrammatic illustrations, and evaluated with cadaver studies[1–9] with one or perhaps more case reports. Animal models are poor candidates for evaluating these methods, because the sinus membranes of most animals are thicker and more resistant to perforation than those of humans (Fig 4-1). Even raw eggs, which are often used for learning sinus floor elevation procedures, have a much thicker and more resistant amnion than the human sinus membrane. In many clinical studies transcrestal sinus floor elevation is not recommended if the bone of the sinus floor is less than 6 to 7 mm thick. Combining it with simultaneous implant placement is almost always advocated.[10–13]

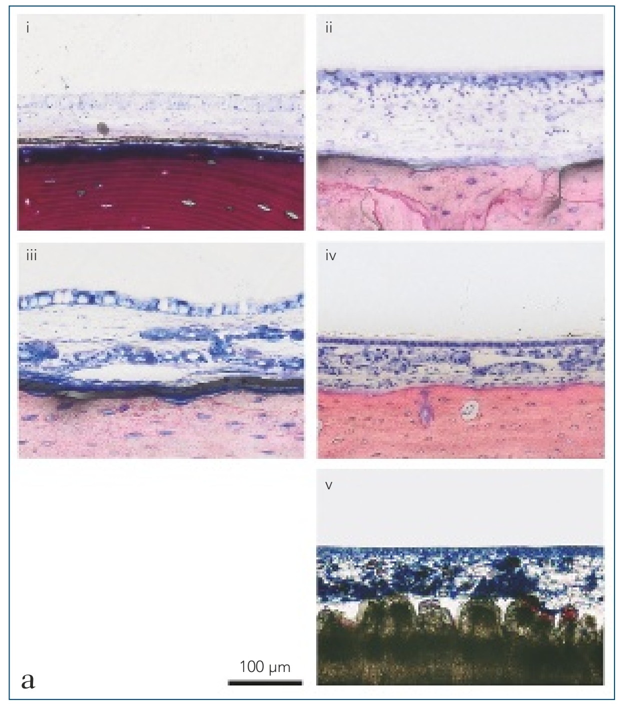
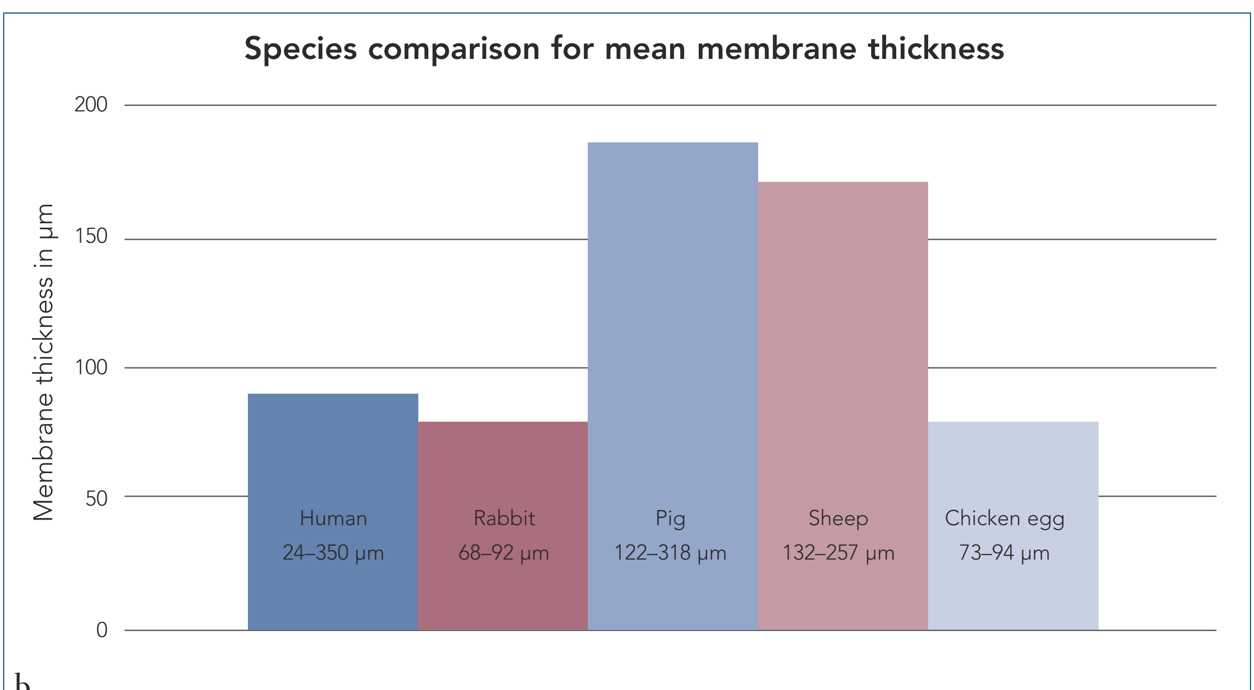


Fig 4-1 (a) Non-decalcified thin ground sections. (i) Human maxillary sinus membrane. (ii) Pig maxillary sinus membrane. (iii) Sheep maxillary sinus membrane. (iv) Rabbit maxillary sinus membrane. (v) Shell membrane of chicken egg. Levai-Laczko stain. (b) Comparison of the thickness of the sinus membrane between different species and shell membrane of chicken egg. The values show wide variation and interspecies differences. The latter helps to characterize the usefulness of the different species for clinical research. (Collection of S. Tangl)



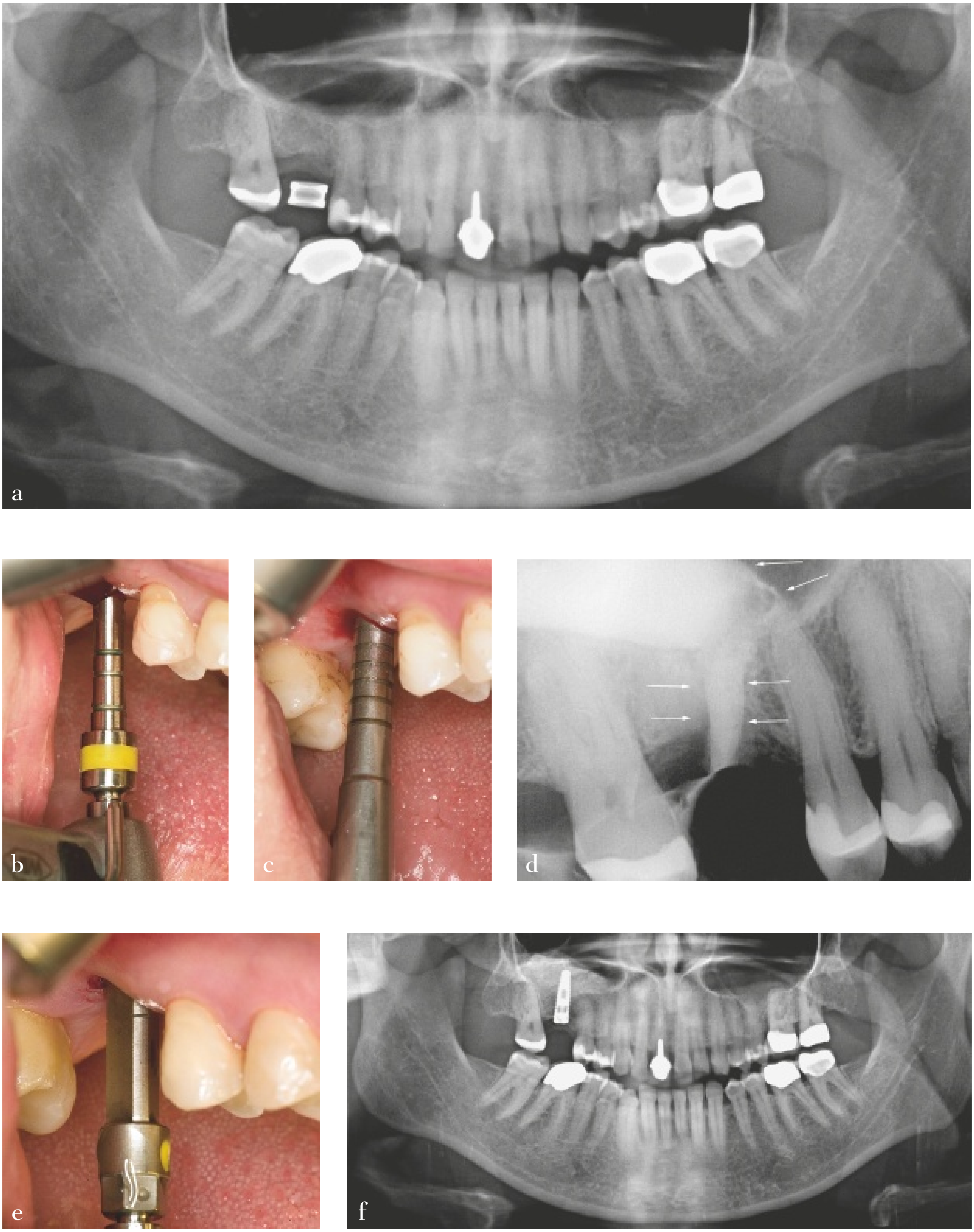


Fig 4-17 Transcrestal sinus floor elevation by gel pressure. **(a)** Baseline panoramic radiograph showing an implant positioning guide at the site of a lost maxillary first molar. **(b)** Pilot osteotomy with gun drill. **(c)** Perforation of sinus floor with an osteotome. **(d)** Exploratory radiograph after sinus membrane elevation with a contrast-containing gel (arrow). **(e)** Implant placement. **(f)** Panoramic radiograph prior to prosthodontic work.

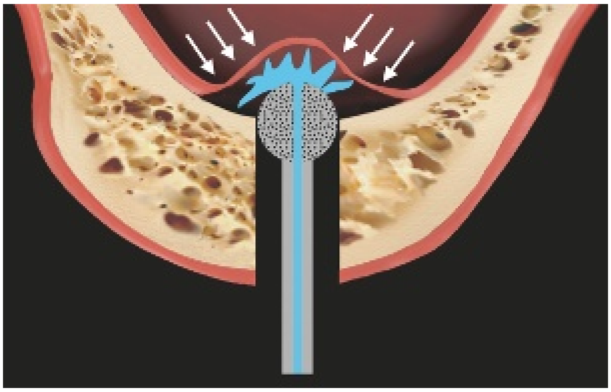


Fig 4-18 Schematic illustrating sinus floor elevation with a strong water jet. The force for elevating the sinus membrane is again strictly upward so that the peak stresses act on the sinus membrane laterally.

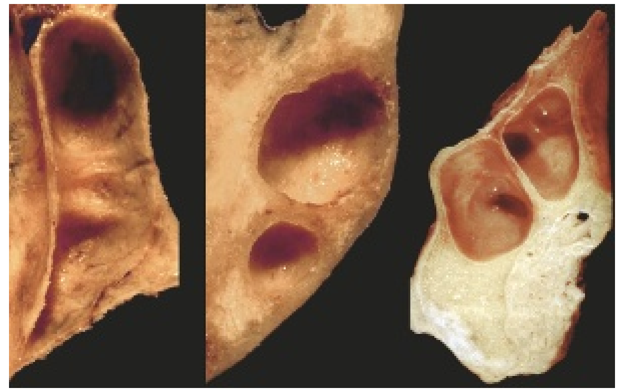


Fig 4-19 In 13 out of 41 skull specimens, Underwood's septa were mainly anterior in the maxillary sinus (30%) and transverse.[66]

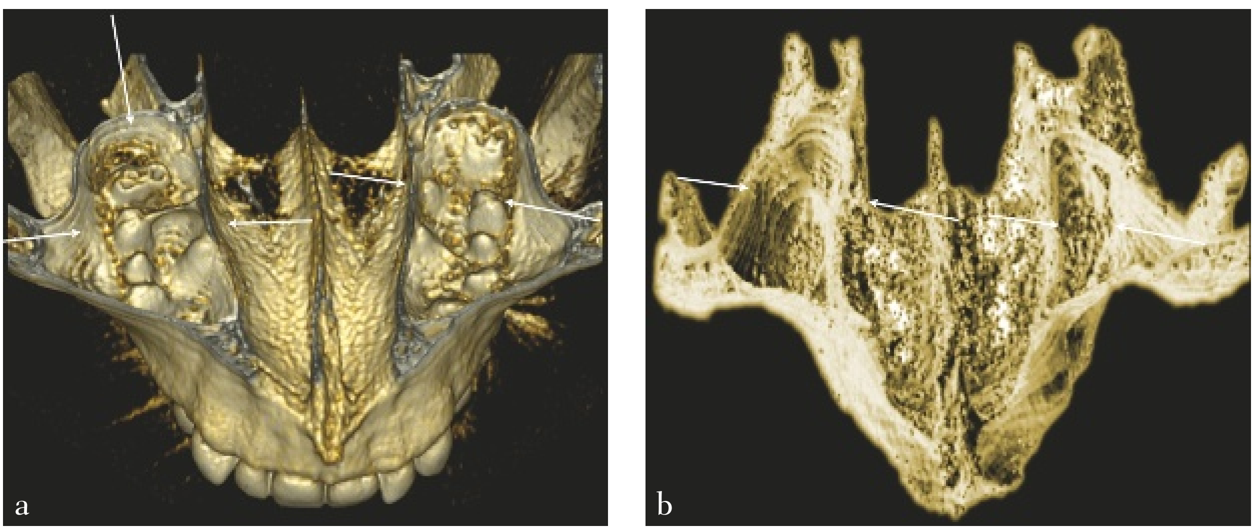


Fig 4-20 Three-dimensional CT image of the sinus floor. **(a)** Note that the sinus floor (arrows) is perturbed and irregular due to the apices of neighboring teeth projecting into the sinus. **(b)** Tooth loss leaves the sinus floor smoother and more regular (arrows).

be expected to guarantee the most uniform distribution of forces with a resultant uniform elevation of the sinus membrane. This is supported by finite-element analyses conducted by Pommer et al. in 2009, which confirmed that the pressure was uniformly distributed across the elevated membrane.[14]

In summary, the pressure exerted should be as uniformly distributed across the sinus membrane as possible to minimize membrane tearing during membrane elevation. Fluid instillation is currently the only technique which meets this requirement.

4.4 Methods for assessing membrane integrity

Once the sinus floor has been perforated and the sinus membrane has been elevated in a circumscribed area, it is important to know whether the membrane has remained intact. Misinterpret-

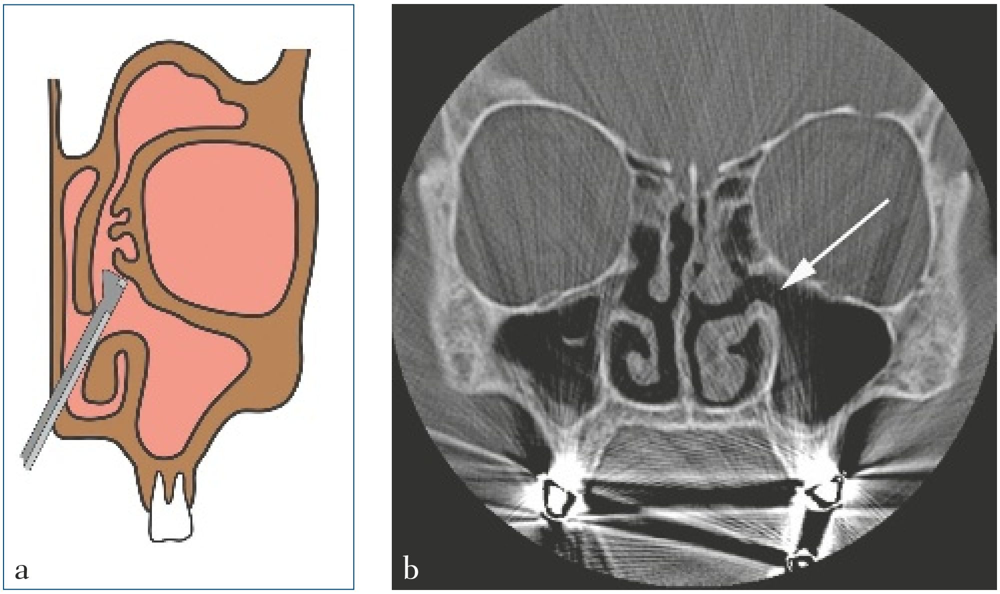


Fig 7-2 a) Schematic illustrating endoscopic infundibulotomy. b) Computed tomography of the sinus after left-sided infundibulotomy (arrow).

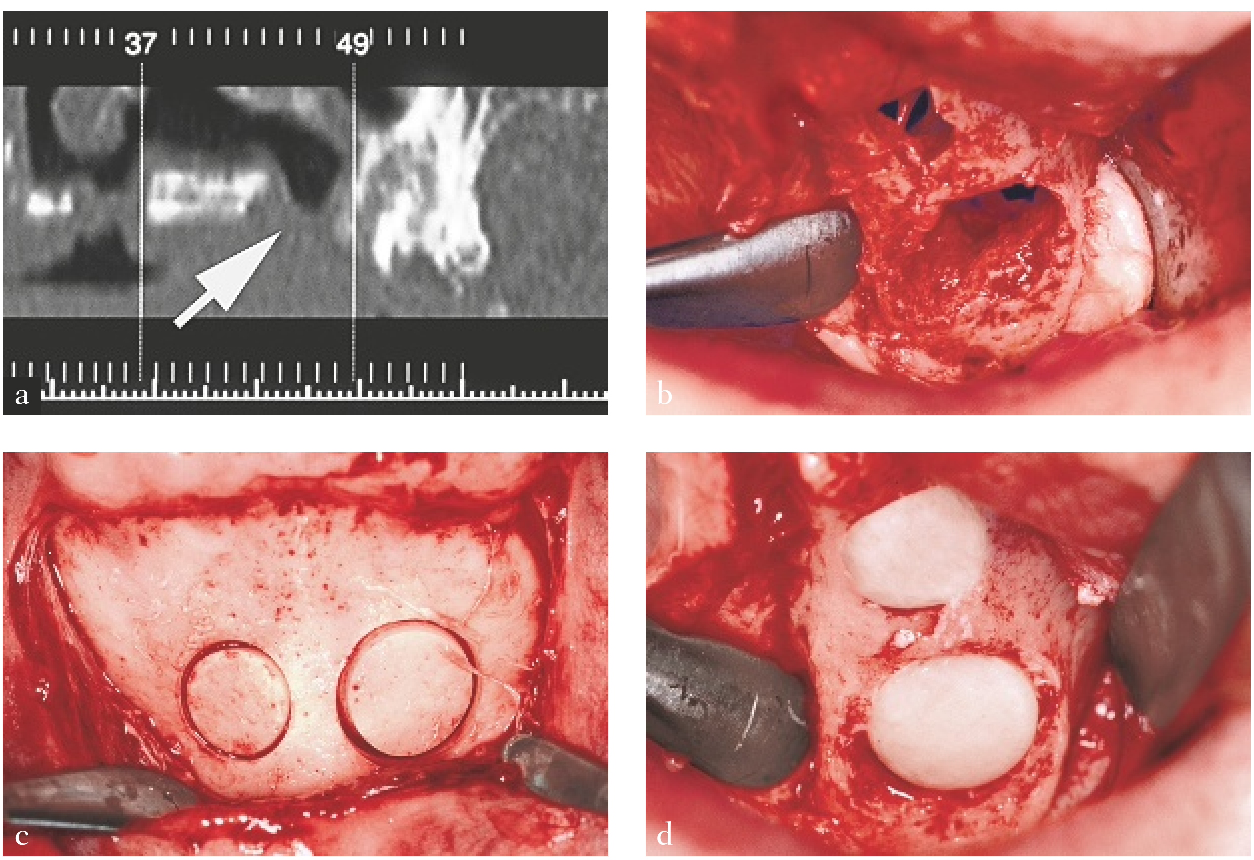


Fig 7-3 (a) Panoramic reconstruction of a dental computed tomography scan showing bone dehiscence after sinus perforation. (b) Intraoperative view of bone dehiscence after healed sinus perforation.[5] (c) Intraoperative view of bone being harvested with a trephine from the chin for repairing the sinus floor.[5] (d) Intraoperative view of sinus floor repaired with bone grafts.[5]

polyps should also be removed by surgery before transcrestal sinus floor elevation to make sure that the sinus membrane is normal.[3,4] If there was an oro-antral communication at the site of interest at any time prior to transcrestal sinus floor elevation, the integrity of the sinus floor should be evaluated with particular care. Bone grafting to restore the sinus floor is usually required in these cases to prevent fusion of the sinus membrane with the oral mucosa without any interposed bone layer[5] (Figs 7-3a to 7-3d).

Other local inflammatory conditions such as periodontal disease or chronic apical periodontitis should also be controlled preoperatively to avoid spread of infection to the surgical site postoperatively.[6–9]

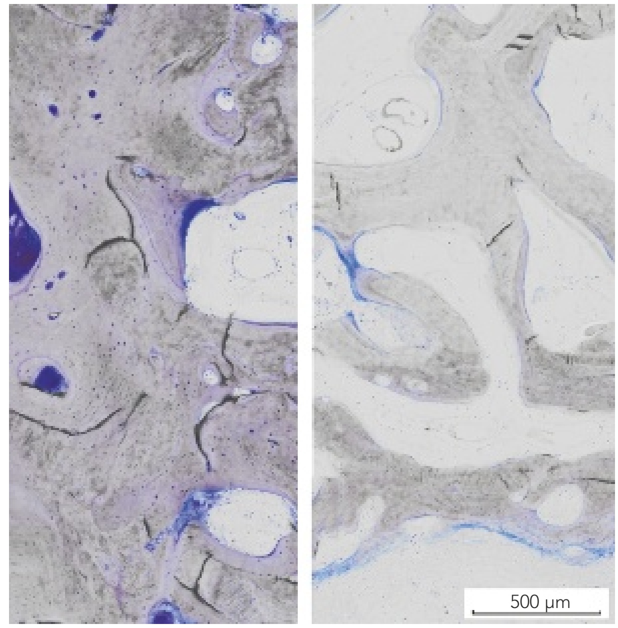


Fig 7-4 Histology of bone biopsies taken with a trephine after sinus floor elevation. **(a)** Biopsy sample from an elderly woman. **(b)** Biopsy sample from a young woman (Reich et al. manuscript in preparation).

7.4 General preoperative work-up

Eliciting a meticulous general medical history preoperatively is also essential for reducing postoperative complications. Many systemic factors such as the patient's age, or presence of diabetes mellitus or osteoporosis, affect bone turnover and may thus interfere with the formation of new bone after transcrestal sinus floor elevation. This is why risk factors should be known prior to surgery and accounted for during treatment planning.

7.4.1 Patient age

In line with current demographics, the age of patients seeking implant treatment, most of whom are also in need of sinus floor elevation, is rising. With increasing age, the risk of age-related diseases such as osteoporosis increases, while the regenerative potential of cells decreases. Bone is also subject to age-related changes. Bone mass drops by a quarter by the age of 60 years.[10] This is associated with increased porosity and more empty osteocyte lacunae.[11] With increasing age there is also a decrease in the number and function of many cells, e.g. the endothelial progenitor cells, mesenchymal cells, and osteoblasts.[12] Age-related endothelial dysfunction and reduced vascular endothelial growth factor (VEGF) expression impair angiogenesis, which is a prime requirement for osteoneogenesis.[13] Females appear to be more affected by the loss of bone regenerative potential than males (Reich et al. manuscript in preparation) (Fig 7-4). However patient age appears to have less influence on bone regeneration in this area than other risk factors[14] so that it carries a lower risk for patients undergoing minimally invasive surgery such as transcrestal sinus floor elevation.[15]

7.4.2 Diabetes mellitus

Diabetes mellitus also affects many factors that are important for bone regeneration. In type 1 diabetes, in particular, bone mineral density is reduced with a resultant significantly higher fracture risk.[16] Studies have found a reduction in osteoblast activity, osteocalcin, and insulin-like growth factor 1 levels in diabetic people com-

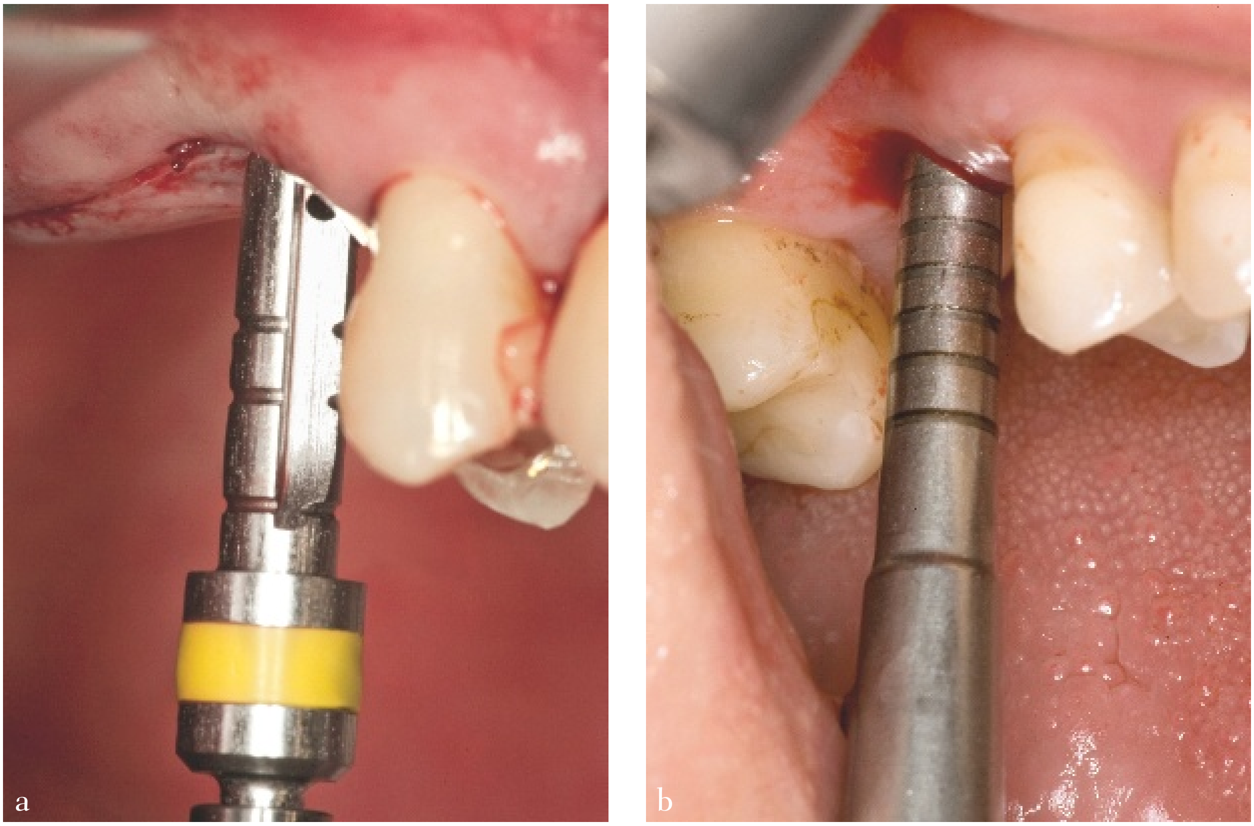


Fig 10-6 Sinus trephination with gun drills (a) or osteotomes (b).

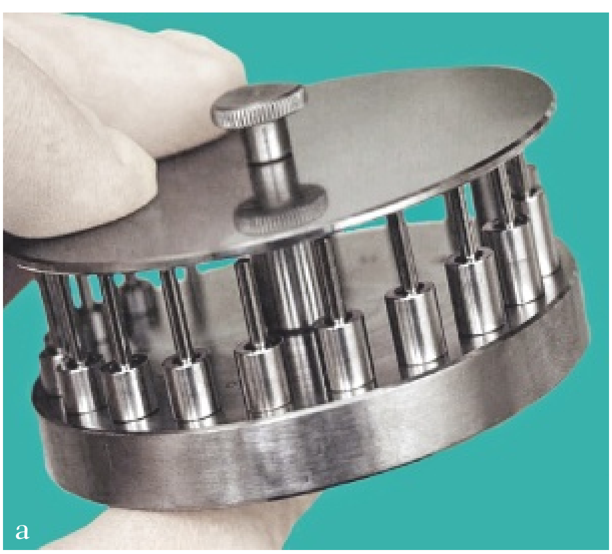


Fig 10-7 (a) Spacer kit for the burrs to be used. Spacers are available for half-millimeter steps. (b) Spacer mounted on gun drill.

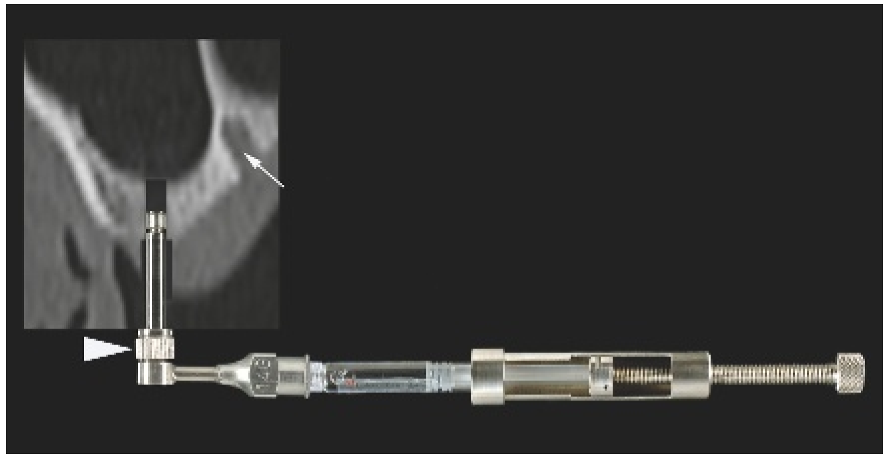


Fig 10-8 Schematic showing drill hole obturation on a sinus CT. (The palatal foramen is indicated by the arrow) Turning a screw nut (arrowhead) expands the silicon ring at the tip of the nozzle for sealing the drill hole. The syringe mounted on the nozzle contains the liquid for membrane elevation. Its plunger is operated by turning the screw-shaped nut rather than by digital pressure.

10.4 Liquid-pressure-mediated membrane elevation

Following successful sinus trephination, an injection nozzle is advanced into the transcrestal osteotomy and positioned 1 to 3 mm from the sinus floor (Fig 10-8). Turning the screw nut compresses the silicone ring at the tip of the nozzle for tightly obturating the osteotomy canal (Fig 10-9a) and securing the nozzle in place (Fig 10-9b). The other end of the injection nozzle is attached to a mechanical device designed to limit the pressure to 1 bar at most.

To separate and elevate the sinus membrane from the bony sinus floor a radiopaque liquid or gel is injected between the two structures (Fig 10-10). The gel consists of 2% hydroxypropyl methyl cellulose (HPMC), a viscoelastic agent, and 37% iopamidol, a radiopaque marker, mixed at a ratio of 3:1. Purified trypan blue (sterile 0.055% solution) added to the transparent gel makes it more visible intraoperatively.[25] HPMC is a high-molecular-weight, water-soluble polymer, which is used in ophthalmic cataract surgery[26] for gently opening the space needed for the procedure and protecting the tissues.[27] A 2% HPMC solution is easily washed out,[28] but does not cause a significant inflammatory response when

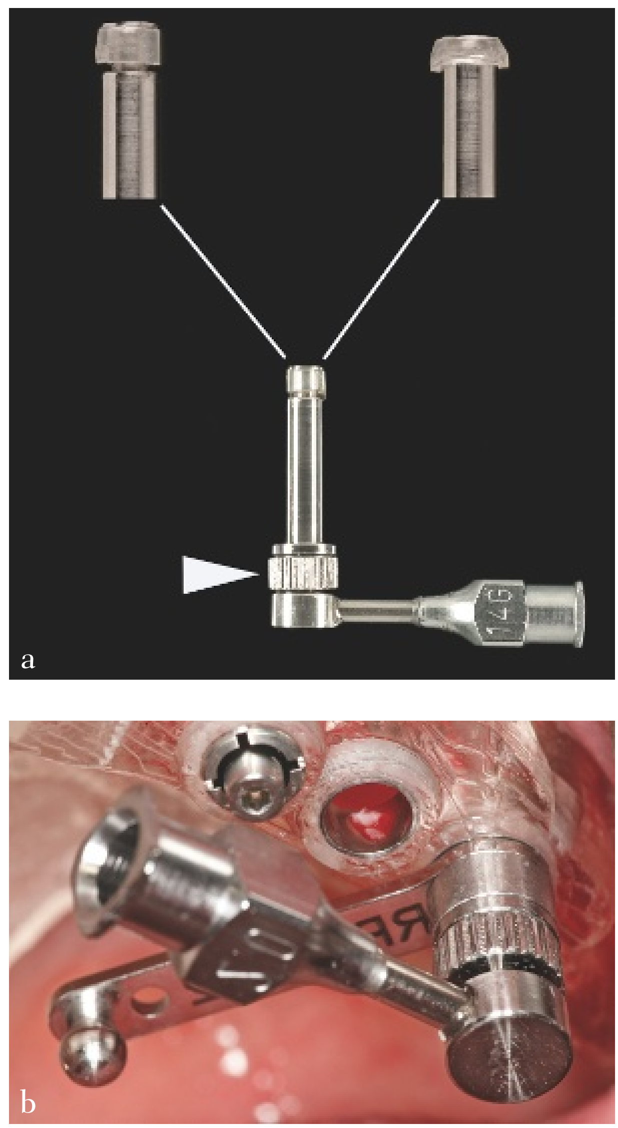


Fig 10-9 (a) Nozzle used for obturating the drill hole. Turning the screw nut (arrow) expands the silicon ring at the tip of the nozzle for sealing the drill hole. (b) Obturating nozzle in place during the procedure.