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# Effects of sinus lifting on voice quality

## A prospective study and risk assessment

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**Abstract:** A variety of potential complications associated with sinus lift surgery have been reported in the literature. However, potential alterations of voice quality following sinus elevation have so far not been mentioned or evaluated scientifically. For the majority of patients, slight changes of the voice pattern are of no importance. However, for voice professionals, whose voices have become part of their distinctive profession or trademark, minimal changes may have dramatic consequences. This specific group of patients, such as speakers, actors and singers, depend on the particular quality and timbre of their voice for their livelihood. Consequently, the purpose of this study was to assess the effects of sinus lifting on voice quality in the above patient group. In a collaborative interdisciplinary effort, the Departments of Oral Surgery and Otorhinolaryngology, Section of Phoniatics and Logopedics, thoroughly evaluated a series of voice parameters of four patients undergoing sinus lifting pre- and postoperatively. The parameters analyzed included pitch, dynamic range, sound pressure level, percent jitter, percent shimmer and noise-to-harmonics ratio with special emphasis on formant analysis. No changes were detected in any of the commonly evaluated parameters. These were rated subjectively by patients and their friends or relatives and objectively with instrumental tools under isolated phoniatic lab conditions. In conclusion, sinus lift surgery appears to be a safe, predictable evidence-based method for regenerating the highly atrophic posterior maxilla, which does not jeopardize the individual characteristic voice pattern of high-profile patients critically dependent on their voices for their livelihood.

## Introduction

Sinus floor elevation has become an established technique for generating maxillary bone compromised by atrophic bone loss (Geiger & Pesh 1977; Tatum 1986; Misch 1987). Its outcome is predictable and its long-term results have been evaluated (Olson et al. 2000). Two techniques are used: the classical approach through a lateral window and, for less severe bone

loss, the osteotome technique (Summers 1994, 1998; Horowitz 1997; Zitzmann & Scharer 1998; Baumann & Ewers 1999).

The potential effects of sinus lifting on voice quality have so far not been addressed in reported studies. As sinus lifting reduces the size of the maxillary sinus, so that the resonant volume of the paranasal sinus system becomes smaller, alterations in voice quality cannot altogether be ruled out at least in theory. This particularly

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applies to nasality. Alterations in voice quality secondary to nasal cavity and paranasal sinus surgery have been reported (Chen & Metson 1997; Hosemann et al. 1998).

Alterations in the distinctive personal voice quality are usually annoying for the patients. For professional voice users, they may be disabling. For persons professionally relying on their voices like singers, speakers, actors as well as speech therapists, even minor modulations may have existential implications and constitute an unacceptable risk. As a rule, voice or rather its quality and timbre is associated with a particular person and is unique for this person. For voice professionals, it is a distinctive sign and may even be a personal trademark. This is why this selected group of patients is entitled to evidence-based information on the predictability of the surgical intervention and its potential risks pre-operatively. Evidence-based information about the predictability of treatment is also important legally in terms of medical liability, because voice alterations, if any, are irreversible.

Vocal sound is generated by vibrations of the vocal folds. These give rise to a spectrum of sounds rather than to a single sound. The sound with the lowest pitch is called fundamental. The whole-number multiples above it are known as harmonics (Kent 1993; Sundberg 1997; Story et al. 1998). As this spectrum passes through the acoustic system, it is subject to amplification, dampening and superimpositions. As a result, part of the spectrum is extinguished. What remains is perceived as a person's individual voice (Kent 1993; Wendler et al. 1996; Sundberg 1997). The resonance of the vocal tract, which is composed of all supraglottic ventilated spaces, i.e. the endolarynx, the pharynx, the mouth, the nasal cavity and the paranasal sinuses, modulates the primary sound in a characteristic way (Fant 1960). What role the maxillary sinus plays as a resonant cavity for the human voice was shown in a study investigating the effects of prosthetic and epithetic repair of the maxilla and its resonant cavity on eliminating nasality in maxillectomized patients (To-bey & Lincks 1989).

Transitory alterations in voice quality are known to occur in patients with inflammatory obstruction of the maxillary sinus,

i.e. sinusitis or rhinitis (Cecil et al. 2001). In patients undergoing extensive sinus floor elevation, similar alterations are at least conceivable and cannot be ruled out without conclusive scientific evidence.

This gave rise to the investigation of the effects, if any, of sinus lifting on changes in voice quality and in particular in vocal resonance both subjectively by questioning patients and those close to them and clinically under lab conditions.

## Material and methods

To be selected for this study patients had to fulfill three criteria, i.e. (1) express request for implant treatment, (2) edentulous and highly atrophic posterior maxillas with inadequate residual ridge height for single-stage augmentation and implant placement, and (3) readiness to undergo phoniatric studies pre- and postoperatively. Four patients were enrolled, three of them female and one male. The age of the female patients was 40, 55 and 66 years. The male patient was 71 years old. Mean patient age was 58 years.

Sinus lifting was done in general anesthesia as detailed in the protocol of the Department of Oral Surgery at the Vienna University Medical and Dental School. To prevent intra-operative stress and control local bleeding, a local anesthetic, i.e. articain hydrochloride, 4–8 ml, mixed with epinephrine (Ultracain dental Forte<sup>®</sup>, Hoechst Marion Roussel, Vienna, Austria), was added. Based on a meticulous preoperative diagnostic work-up by dental computed tomography (d-CT), access to the maxillary sinus was gained through a lateral window by reflecting the bone flap attached to the sinus membrane. Then Schneider's membrane (sinus endothelium) was elevated from occlusal and buccal towards nasal without disruption. To control the amount of bone to be generated and its precise site a surgical template made from a prosthodontic set-up was used. This ensured state-of-the-art per-protocol prosthetic-driven implant placement planned collaboratively by the prosthodontist and the surgeon. Cancellous autografts from the iliac crest mixed with Bio-Oss<sup>®</sup> at a ratio of 3 : 1 and platelet-rich plasma (PRP) were introduced through the lateral windows in the maxilla bilaterally. Recent reports indicated that cancel-

lous autografts, while abundantly available from the iliac crest, were subject to massive resorption, which can largely be prevented by admixing bone substitutes like Bio-Oss<sup>®</sup> (Haas et al. 1998, 2002; Watzek et al. 1998). Perioperative medication consisted of antibiotics (amoxicillin and clavulanic acid = Augmentin<sup>®</sup>, Smith-Kline Beecham Pharma, Austria), 2 g daily for 7 days, anti-inflammatories and analgesics (mefenaminic acid = Parkemed<sup>®</sup>, Parke-Davis, Vienna, Austria), 1500 mg daily for 7 days. A nasal decongestant (oxymetazoline = Nasivin<sup>®</sup> 0.05% nose drops, Merck, Vienna, Austria), t.i.d. or q.i.d. bilaterally for 7 days, was added to facilitate sinus ventilation. The patients were watched for 24 h postoperatively and discharged home on the first postoperative day. Six months after sinus elevation and after completing the studies described in this contribution, all patients received four implants on either side and were provided with either removable bar-retained or nonremovable screw-retained dental work. Loading has so far been uneventful clinically.

All patients routinely underwent radiologic studies pre- and postoperatively. These included OPGs (orthopantomography) and d-CTs. High-resolution scans of the maxilla were acquired with a conventional CT scanner (Tomoscan SR-6000, Philips, Eindhoven, The Netherlands) using a low-dose dental CT investigation protocol (1.5 mm slice thickness, 1.0 mm table feed, 120 kV, 50 mA, 2 s, high-resolution bone filter). With this low-dose protocol, the radiation dose rendered to the patients is 93% lower than that of conventional CT protocols (Gahleitner et al. 2001).

To assess the sinus volume preoperatively and the size of the grafts and of the residual sinuses postoperatively, axial slices were acquired from the occlusal plane to the orbital floor. These were color-coded with the ADOBE Photoshop software, version 5.0, which showed the ventilated sinus volume in blue and the solid grafts in red. Scans with a slice distance of 1 mm were pooled for computing volumes. For volumetric reconstruction the LUCIA VGA software, version 4.51, was used. In a comparative evaluation the method used was found to provide the most accurate volumetric information about the sinus and graft volumes. Its usefulness is well docu-

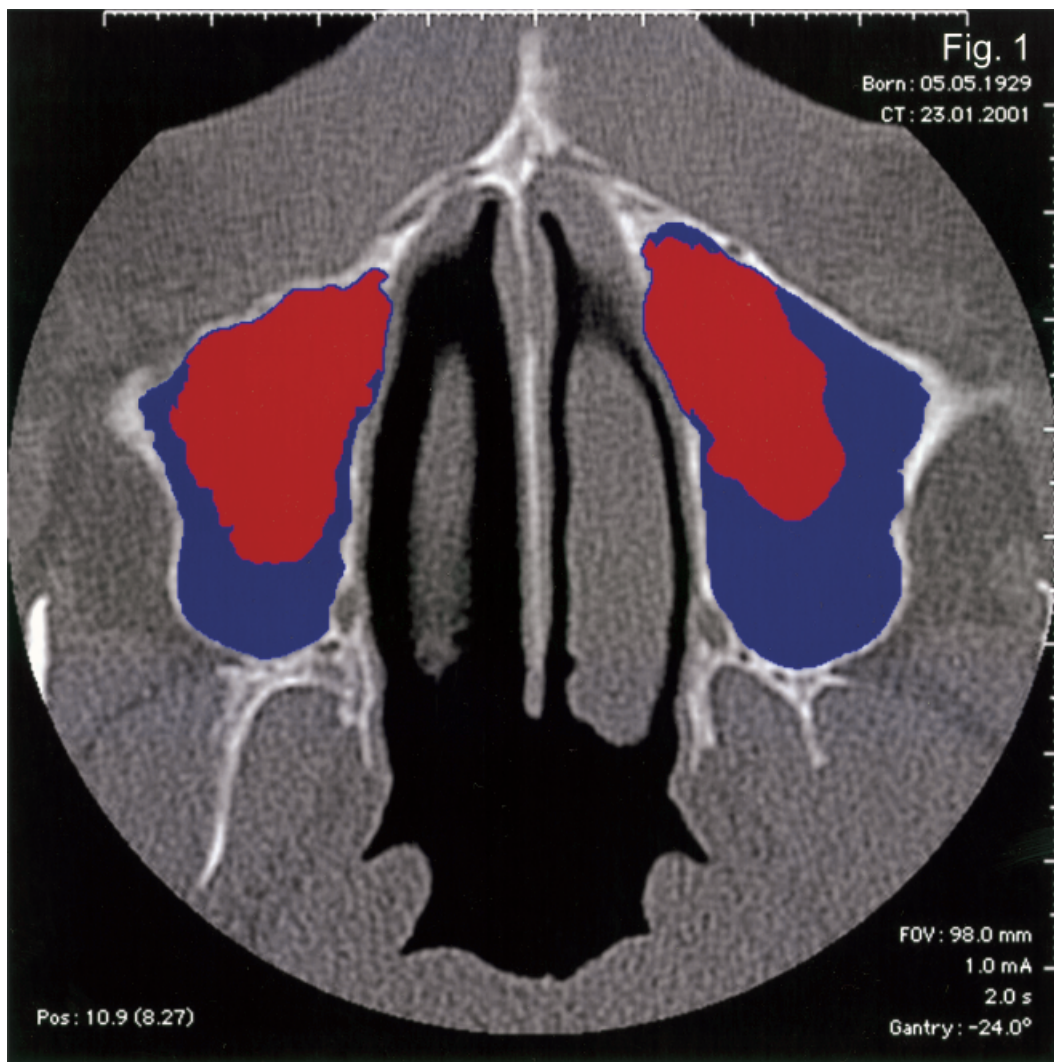


Fig. 1. Color-coded sinus and graft volumes: red represents the sinus lift and blue the maxillary sinus

mented in the literature (Jensen et al. 1998a, 1998b; Uchida et al. 1998a, 1998b). Fig. 1 shows an example of the color-coded sinus and graft volumes.

#### Phoniatic and logopedic studies

The phoniatic studies were performed by an experienced examiner at the Department of Otorhinolaryngology, Section of Phoniatics and Logopedics, University of Vienna Medical School, before surgery and 2 weeks postoperatively. As the postoperative phoniatic follow-up of the sinus-lifted patients was delayed until after the surgery-related lesions had healed completely, additional studies at a later time were unnecessary. To rule out any examiner bias, the examiner was blinded to the pre- and postoperative sinus volumes and

graft sizes. All studies were performed with due attention to the Guidelines of the European Laryngological Society (Dejonckere 2000). Preoperative risk factors and abnormalities, if any, were elicited from the patients' history and by phoniatic studies. These included auditory perceptual assessment, otoscopy, rhinoscopy and pharyngoscopy, videostroboscopy, voice range profile analysis and computer-assisted auditory assessment and were repeated postoperatively to identify any changes. For assessing the singing and speaking voice profiles, the standardized protocol recommended by the Union of European Phoniatics was followed (Seidner and Schutte 1982). The head microphone used for recordings was set for an ambient noise level of <40 dB in the examination room.

From the singing voice range profiles elicited pre- and postoperatively, the variables below were computed:

- frequency range of singing voice (FR) in semitones (ST) and
- evaluation of voice constitution as 'normal' with a standard value for maximum sound pressure level (SPL<sub>max</sub>) of at least 90 dB.

The speaking voice range profiles were used for determining the

- fundamental frequency of habitual speaking voice in Hz,
- frequency of shouting voice in Hz,
- SPL of shouting voice in dB and
- dynamic range, i.e. the difference between the sound pressure levels of shouting and habitual speaking voices in dB.

Functional voice assessment consists of both perceptual and acoustic investigations. Consequently, both subjective perceptual assessments with the standard RBH scale (R = roughness, B = breathiness, H = hoarseness) and digital voice recordings were made. Digital voice recordings were obtained for further spectral analyses. Roughness, breathiness and hoarseness were rated on a four-point scale (0 = normal normal or no deviance, 1 = slight deviance, 2 = moderate deviance, 3 = severe deviance). Voice quality was assessed during conversational speech at habitual pitch and loudness. The nasal component of the vocal sound was also evaluated. To quantify auditory perceptual parameters, the Göttingen Hoarseness Diagram (rp-Szene) was added to the RBH scale. Selected vowels (/a:/, /e:/, /i:/, /o:/, /u:/) were phonated at a comfortable pitch and loudness and at a 'very loud' level (/a:/ as in 'after', /e:/ as in 'face', /i:/ as in 'me', /o:/ as in 'more' and /u:/ as in 'soup'). The patients were instructed to sustain the vowels for at least 5 s. With the computer-assisted Göttingen Hoarseness Diagram, periodicity analyses were made. These were used to describe irregularities or roughness by measuring percent jitter (frequency variation of consecutive vibrations), percent shimmer (peak-to-peak amplitude variation) and the mean perturbation correlation as well as the noise components and the breathiness by assessing the glottal-to-noise excitation ratio (GNE) (Klingholz 1986; Fröhlich et al. 1998). In addition, the standard text 'Nordwind und Sonne' generally used in the German-speaking countries was recorded for subsequent analysis. Two-second sequences of the vowels /a:/, /i:/ and /u:/ voiced at normal loudness were subjected to spectral analysis for formant quantification with the Multidimensional Voice Program (MDVP) – Computerized Speech Lab (CSL) of Kay Elemetrics Corporation, Lincoln Park, NJ, USA. Formants are energy peaks in the overall voice spectrum (Fant 1960; Maurer et al. 1991). The relative energy levels of the first 3 formants (F1–F3) were determined by fast fourier transformation (FFT). To eliminate any examiner bias, the first three harmonics (H1–H3) were also considered as whole-number multiples of the fundamental in the voice spectrum.

To complete the assessment made by objective lab analyses, both the patients

themselves and those close to them were questioned about subjectively perceived voice changes, and the postoperative voice was compared with preoperative digital voice recordings by experienced listeners.

## Results

### Postoperative course

All patients made an uneventful recovery by CT, OPG and clinical evidence. They were discharged home after 24 h. The medication described earlier was continued for 7 days, i.e. the time of suture removal. On CT the grafts showed a homogeneous structure and normal ossification without signs of poor integration. In one female patient, thickening of the sinus endothelium was found incidentally. This had been present preoperatively and was clinically asymptomatic. To rule out a falsifying effect on the data, the thickness and volume of the sinus membrane was determined volumetrically and deducted from the graft and sinus volume.

### Volumetric analysis

The mean sinus volume was 18.156 cm<sup>3</sup>. The graft size accounted for 16.5% of the

original sinus volume with a range of 13.1–22.6%.

Table 1 lists the computed pre- and postoperative sinus and graft volumes in cubic centimeters and percent.

### Phoniatic and logopedic analysis

#### Subjective voice rating

When questioned postoperatively, none of the patients reported any perceived alterations in timbre and other voice characteristics vs. pretreatment. Similarly, those close to them did not perceive any voice changes.

A comparison of pre- and postoperative voice recordings did not provide any evidence of alterations in timbre and voice quality. This particularly applied to articulation and intelligibility. Alterations of the nasal component were also absent by auditory perceptual evidence. Preoperative auditory perceptual assessment with the RBH scale had been suggestive of a normal voice quality (Ro Bo Ho) in two patients. One female patient scored R1–2 Bo H1–2, i.e. slightly to moderately rough and hoarse; another female patient scored R1 Bo H1, i.e. slightly rough and hoarse. These ratings were unchanged postoperatively.

**Table 1. Volumetric analysis in cm<sup>3</sup> and %**

Patient	V <sub>sin l+r pre</sub>	V <sub>aug l+r</sub>	V <sub>sin postop</sub>	V <sub>muc</sub>	V <sub>%aug l+r</sub>	V <sub>%sin l+r</sub>	V <sub>%muc l+r</sub>
1	23.5	5.3	18.2	0.0	22.6	77.4	0.0
2	31.6	4.7	26.9	0.0	15.0	85.0	0.0
3	47.6	7.3	31.8	8.5	15.3	66.8	17.9
4	42.5	5.6	37.0	0.0	13.1	86.9	0.0
Mean	36.3	5.7	28.5	—	16.5	79.0	—
Right maxillary sinus							
	V <sub>preop</sub>	V <sub>aug</sub>	V <sub>sin postop</sub>	V <sub>muc</sub>	V <sub>%aug</sub>	V <sub>%sin</sub>	V <sub>%muc</sub>
1	15.5	3.6	11.9	0.0	15.2	84.8	0.0
2	15.8	2.4	13.5	0.0	7.4	92.6	0.0
3	21.0	4.4	16.1	0.5	9.2	89.7	1.1
4	21.0	3.5	17.5	0.0	8.1	91.9	0.0
Left maxillary sinus							
	V <sub>preop</sub>	V <sub>aug</sub>	V <sub>sin postop</sub>	V <sub>muc</sub>	V <sub>%aug</sub>	V <sub>%sin</sub>	V <sub>%muc</sub>
1	8.1	1.8	6.3	0.0	7.5	92.5	0.0
2	15.8	2.4	13.4	0.0	7.6	92.4	0.0
3	26.5	2.9	15.7	8.0	6.0	77.1	16.8
4	21.5	2.1	19.4	0.0	4.9	95.1	0.0

V<sub>sin l+r pre</sub>: total preoperative volume, left and right sinus; V<sub>aug l+r</sub>: total graft volume, left and right sinus; V<sub>sin postop</sub>: postoperative sinus volume; V<sub>muc</sub>: volume of sinus membrane; V<sub>%aug l+r</sub>: percent grafted left and right sinus; V<sub>%sin l+r</sub>: percent residual preoperative volume after sinus lifting, left and right sinus; V<sub>%muc l+r</sub>: percent sinus membrane of total preoperative sinus volume, left and right sinus; V<sub>preop</sub>: preoperative sinus volume; V<sub>aug</sub>: graft volume; V<sub>%aug</sub>: percent grafted sinus; V<sub>%sin</sub>: percent residual preoperative sinus volume after sinus lifting; V<sub>%muc</sub>: percent sinus membrane of pre-operative sinus volume.

Phoniatric otoscopy, rhinoscopy and pharyngoscopy

Otoscopy, rhinoscopy and pharyngoscopy were within normal for the patients' age. One female patient was incidentally found to have Reinke's edema of the vocal folds. She was put on drug treatment and entered in a phoniatric follow-up program.

#### Voice profile analysis

For the sake of completeness, phoniatric parameters describing voice constitution were also considered in the study. A comparison of the baseline and the post-operative data showed minor intraindividual variations well within the range of normal day-by-day variability. The discrete deterioration in voice quality clinically suspected in patient #4 and the slight improvement vs. baseline in patient #3 were not corroborated by auditory perceptual evidence. Table 2 lists the outcome of singing and speaking voice analyses.

#### Periodicity analysis

The periodicity data, i.e. perturbation correlation, percent jitter, percent shimmer, irregularity, glottal-to-noise excitation ratio and noise, are shown in Table 3 in different phonation conditions. A comparison of the data before and after sinus lifting showed minor alterations well within the range of day-by-day variability. These were not detectable by auditory studies.

#### Spectral analysis

The relative energy levels of the first three formants (F1–F3) and the first 3 harmonics (H1–H3) pre- and postoperatively are shown in Table 4. The traces were interpreted by experienced examiners. No clinically relevant differences between pre- and post-treatment data were detected. Fig. 2 shows an example (patient #3) of the pre- and postoperative formant traces.

## Discussion

In a number of studies, objective lab tests showed the paranasal sinuses to be an important part of the resonant system (Masuda 1992; Dang & Honda 1996; Koyama 1996; Vasilenko et al. 1997). On account of its volume the paired maxillary sinus contributes overproportionately to this system. Almost a century ago the sinus volume was reported to vary widely

**Table 2. Results of singing and speaking voice range profile measurements**

Patient	FR	SPL of loud singing voice>90 dB	Frequency of habitual speaking voice (Hz)	Frequency of shouting voice (Hz)	DR (ST)	SPL of shouting voice>90 dB
1. S.E.						
preop	24	Yes	135	262	30	No
postop	24	Yes	135	262	29	No
2. H.H.						
preop	24	Yes	196	254	32	No
postop	31	Yes	196	288	35	Yes
3. M.E.						
preop	24	No	196	277	23	No
postop	28	No	196	288	26	Yes
4. N.W.						
preop	27	No	131	196	31	Yes
postop	27	No	131	196	31	Yes

SPL: sound pressure level; FR: frequency range of singing voice; DR: dynamic range of speaking voice.

**Table 3. Mean values of the voice perturbation parameters**

Patient	PTC	Jitter %	Shimmer%	Irregularity	GNE	Noise
1. S.E.						
preop	0.934	0.51	1.57	2.67	0.523	2.21
postop	0.997	0.30	2.41	2.96	0.355	2.01
2. H.H.						
preop	0.989	0.34	4.49	3.87	0.404	2.70
postop	0.999	0.30	1.97	2.50	0.653	1.67
3. M.E.						
preop	0.997	2.10	4.12	3.30	0.420	2.64
postop	0.997	0.21	2.37	2.85	0.506	2.28
4.N.W.						
preop	0.996	1.38	3.98	3.43	0.617	1.82
postop	0.998	3.03	4.62	3.41	0.538	2.15

PTC: perturbation correlation; GNE: glottal-to-noise excitation ratio.

from 9.5 to 20 cm<sup>3</sup> with a mean volume of 14.75 cm<sup>3</sup> (Schaefer 1910). These volumes are relatively smaller than those we found, because they were derived from fully dentate skulls without atrophy-related sinus pneumatization.

In this study, the sinus volume was routinely reduced by preprosthetic sinus floor elevation by as much as 22%. As the results showed, this reduction did not entail any subjectively perceived or objectively verifiable voice changes of a transitory or permanent nature. Such minor day-by-day amplitude variations as were seen had no clinical implications.

The results of this study do not confirm reports indicating that the resonant characteristics of the maxillary sinus vary as a function of the sinus size and volume (Masuda 1992). These reports were based on studies of anatomical variants without any pathologies, without comparative pre- and postoperative data following surgical

**Table 4. Relative energy levels (amplitudes) of the first 3 formants (F1–F3) and the first three harmonics (H1–H3) pre- and post-operatively**

Patient	F1	F2	F3	H1	H2	H3
1. S.E.						
/a:/	↓	↓	↓	↑	↓	↓
/i:/	↑	↑	↑	↑	↑	↑
/u:/	↑	=	↓	↑	↑	↓
2. H.H.						
/a:/	↑	↑	↑	↑	↑	↑
/i:/	↓	↓	↓	↓	↓	↓
/u:/	↓	↓	↓	=	=	↑
3. M.E.						
/a:/	↑	↑	↑	=	↑	↑
/i:/	=	↓	↑	=	↑	↓
/u:/	=	↓	=	=	↑	↓
4. N.W.						
/a:/	↑	↑	↑	↑	↑	↑
/i:/	↓	↑	↓	=	↓	↓
/u:/	↑	↓	↓	↓	↓	↑

manipulation of the paranasal sinus system and without regard to the sinus volume. A comparative study showed postoperative

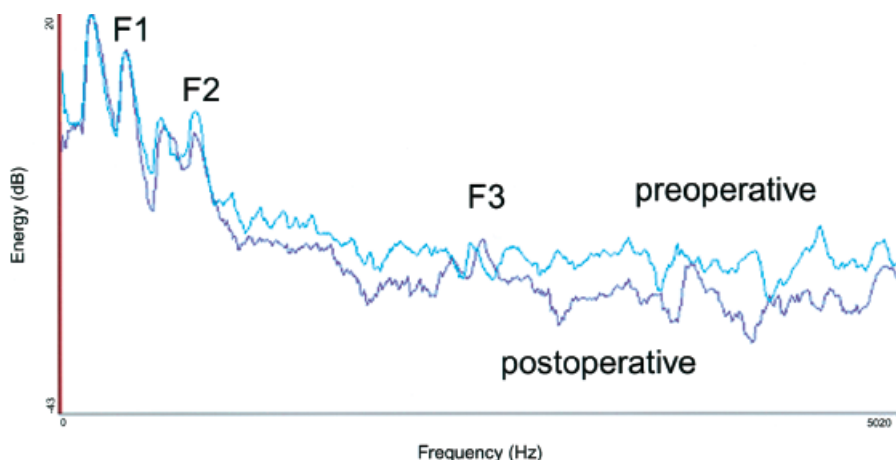


Fig. 2. Example of pre- and postoperative formant traces: patient #3, sustained vowel /u:/.

voice alterations following endoscopic maxillary sinus surgery in one-third of the cases. These alterations were both subjectively perceivable and verified by spectral analysis (Hosemann et al. 1998). In another study five patients who underwent endoscopic polypectomy of the maxillary sinus initially complained of increased nasality, which later cleared spontaneously (Chen & Metson 1997). The authors recommended alerting all patients, particularly voice professionals, to this risk prior to elective surgery. Considering that minimally invasive endoscopic procedures may have a substantial effect on voice quality, the results of this study were surprising. Although sinus floor elevation through a lateral window with bone autografts and bone substitutes is much more traumatic than any endoscopic procedure, it did not cause any voice changes. The postendoscopy phenomena reported by others may perhaps be attributable to initial postinterventional congestion following instrumental manipulation of the natural ostium causing temporary blockage of the paranasal resonant cavities. This assumption is supported by the gradual recovery of the original voice quality, once the reactive processes subsided. The mechanisms underlying the clinical phenomena observed appear to be linked to the substantial differences between comparatively traumatic sinus floor elevations and relatively nontraumatic endoscopic procedures. While sinus lifting is not performed, unless the sinus is clear and well ventilated, endoscopic procedures are usually indicated in abnormal sinuses, which generally show inflammatory lesions. Sinus lifting reduces the sinus volume, whereas other proce-

dures increase it, as polyps, etc. are removed. The site of intervention is another important point. Sinus lifting involves the lateral and basal segments of the maxillary sinus without coming anywhere near its ostium and without manipulating the nasal wall except if the sinus is extremely flat. In this case, the graft and the site of manipulation may come close to the natural opening (Nevins & Fiorellini 1999). Although less traumatic anatomically, endoscopic access through the natural opening may nevertheless cause reactive local swelling of the mucosa with resultant impairment of drainage.

Most importantly, sinus lifting is, in essence, an extrasinusoidal procedure, which can ideally be done without disrupting Schneider's membrane. While the sinus endothelium is flattened in the process, other morphological changes, particularly of the goblet cells, are absent, as was shown in histological studies (Haas et al. 1998).

Completion or follow-up endoscopy was omitted, because it would have aggravated the demands made on the patients by additional manipulation prolonging the operating time without providing any further information diagnostically and therapeutically. In fact, minimally invasive endoscopic sinus surgery was shown to cause significant changes in voice quality (Chen & Metson 1997). In light of this and in view of the problem of interest, endoscopic manipulation of whatever kind was felt to be contraindicated. It would have biased the single-purpose objective evaluation of the effects of sinus lifting.

This study documented that, if patients are carefully selected and the procedure is properly done, sinus lifting is unlikely to

have any detrimental effects on voice quality. This aspect is of particular relevance in terms of medical diligence and liability, when counseling professional voice users preoperatively.

## Conclusion

Sinus lifting and the associated reduction of the sinus volume by up to one quarter of the preoperative size does not entail any subjectively perceivable or objectively verifiable alterations in voice quality. With due regard to the legal aspects involved, i.e. medical liability and predictability of treatment outcome, it has a legitimate place even in patients depending on their voices professionally.

## Résumé

Quelques complications potentielles associées à la chirurgie d'épaississement du plancher sinusal ont été rapportées dans la littérature. Les altérations potentielles de la qualité de la voix suivant l'épaississement du plancher sinusal n'ont pas encore été mentionnées et évaluées scientifiquement. Pour la majorité des patients, des petites variations dans le timbre de la voix ne sont pas importantes. Cependant, pour les professionnels de la phonation pour lesquels la voix est devenue une partie importante de leur profession, des variations même faibles peuvent entraîner des conséquences dramatiques. Ce groupe spécifique de patients, tels que les orateurs, les acteurs et les chanteurs dépendent essentiellement de la qualité et du timbre particulier de leur voix dans leur vie professionnelle. Par conséquent, le but de cette étude a été d'estimer les effets d'un épaississement du sinus sur la qualité de la voix dans ce groupe de patients. Dans un effort interdisciplinaire collaboratif, les départements de chirurgie buccale et d'otorhino-laryngologie, la section de phonétique et de logopédie ont évalué de manière très précise une série de paramètres de la voix avant et après l'opération chez quatre patients ayant subi un épaississement du sinus maxillaire. Les paramètres analysés contenaient la hauteur, l'étalement, le niveau de pression du son, le pourcentage de trac, le pourcentage de chatolements et la proportion bruit-harmonie avec une insistance spéciale sur l'analyse du formant. Aucun changement n'a été détecté dans aucun des paramètres évalués couramment. Ces derniers étaient estimés subjectivement par les patients et par leurs amis ou parents, et objectivement à l'aide des instruments sous des conditions de laboratoire de phonétique isolé. En conclusion, la chirurgie d'épaississement du plancher sinusal semble une méthode sûre, avec un pronostic basé sur l'évidence, permettant de régénérer les maxillaires très atrophiés qui n'empêche pas la caractéristique individuelle de la voix chez des patients avec des profils où la voix est essentielle à leur vie active.



## Zusammenfassung

Der Einfluss einer Sinusbodenelevation auf die Stimmqualität, eine Langzeitstudie und Risikoanalyse.

In der Literatur werden eine ganze Reihe von möglichen Komplikationen beschrieben, die bei dem chirurgischen Eingriff der Sinusbodenelevation auftreten können. Veränderungen der Stimme, die als Folge einer Sinusbodenelevation vorkommen können, wurden aber bis heute weder beschrieben, noch wissenschaftlich ausgewertet. Für den Grossteil der Patienten haben leichte Veränderungen der Stimme keine Bedeutung. Für Personen aber, deren Stimme bei der Ausübung ihres Berufes wichtig ist, eventuell ein Teil ihres Berufes oder gar Markenzeichen geworden ist, können kleine Veränderungen dramatische Folgen haben. Diese ausgewählte Gruppe von Patienten, wie zum Beispiel Nachrichtensprecher, Schauspieler oder Sänger, sind im täglichen Leben auf die spezifische Art und den Klang ihrer Stimme angewiesen.

Daher war das Ziel dieser Studie, Einflüsse einer Sinusbodenelevation auf die Stimmqualität bei den oben erwähnten Patienten zu untersuchen. In einer interdisziplinären Zusammenarbeit untersuchten die Klinik für Oralchirurgie und Otorhinolaryngologie und die Abteilung für Phonetik und Logopädie an 4 Patienten vor und nach der Sinusbodenelevation sehr eingehend verschiedene Parameter der Stimme. Die untersuchten Parameter waren Tonhöhe, Tonvolumen, den durch den Ton erzeugten Luftdruck, Schwingungen, Vibrationen und das Verhältnis zwischen Nebengeräuschen und harmonischem Klang mit speziellem Augenmerk auf formative Analysen.

Man erkannte bei keinem der oben untersuchten Parameter eine Veränderung. Sie wurden sowohl subjektiv durch die Patienten und ihre Freunde oder Verwandten, sowie objektiv mit Messinstrumenten unter absolut schallisolierten Laborbedingungen gemessen.

Über die Sinusbodenelevation kann man zusammenfassend sagen, dass es sich um eine sichere, voraussagbare und auf wissenschaftlichen Grundlagen basierende Operationsmethode zum Wiederaufbau einer massiv atrophischen Maxilla im Seitenzahnbereich handelt. Sie gefährdet die individuellen Stimmcharakteristika von kritischen und sehr anspruchsvollen Patienten, die in ihrem täglichen Leben auf ihre charakteristische Stimme angewiesen sind, nicht.

## Resumen

Se han descrito en la literatura una variedad de complicaciones asociadas con la cirugía de la elevación del seno. Pero hasta el momento no se han mencionado ni evaluado científicamente alteraciones potenciales de la calidad de voz tras la elevación del seno. Para la mayoría de los pacientes, pequeños cambios en el patrón de voz no tienen importancia. De todos modos, en los profesionales de la voz, cuyas voces se han convertido en parte distintiva de su profesión o marca, pequeños cambios pueden tener consecuencias dramáticas. Este grupo específico de pacientes, tales como locutores, actores y cantantes, dependen de la calidad particular y timbre de su voz para su sustento. Consecuentemente, el propósito de este estudio fue valorar los efectos de la elevación del seno en la calidad de voz en el anterior grupo de pacientes. En un esfuerzo de colaboración interdisciplinaria, los departamentos de Cirugía Oral y Otorrinolaringología, Sección de Foniatria y Logopedia, evaluaron e profundidad una serie de parámetros de voz de 4 pacientes que se someterían a elevación del seno pre y postoperatoriamente. Los parámetros analizados incluyeron tono, rango dinámico, nivel de presión sonora, porcentaje de reverberación, porcentaje de tremulación y relación ruido a armónicos con especial énfasis en el análisis formante. No se detectaron cambios en ninguno de los parámetros evaluados comúnmente.

Estos se valoraron subjetivamente por los pacientes y sus amigos o parientes y objetivamente por herramientas instrumentales bajo condiciones de laboratorio de aislamiento foniatrico. En definitiva, la cirugía de elevación del seno parece ser un método seguro, predecible basado en la evidencia para regenerar el maxilar posterior altamente atrofico, que no pone en peligro las características del patrón de voz de los pacientes de características especiales dependientes de manera crítica de sus voces para su sustento.

### 要旨

上顎洞挙上術に関連して多様な合併症が文献に報告されているが、上顎洞挙上術後の声質の変化については、今まで報告されておらず、科学的に評価されていない。大半の患者にとっては、わずかな音声パターンの変化は重要ではないが、職業上、声が非常に重要であり、トレードマークの一部となっている者にとっては、わずかな変化でも劇的な結果をもたらす可能性がある。講演者、役者、歌手などの特殊な患者群は自己の声の特別な資質や特徴を生活の糧としている。従って本研究では、上記の患者群において上顎洞挙上術が声質に及ぼす影響を評価した。口腔外科部と耳鼻咽喉科部の音声病学・言語矯正学科の学際的な共同研究において、上顎洞挙上術前後に患者4人の音声パラメータを詳しく評価した。分析したパラメータには、ピッチ、動態的領域、声圧レベル、%ジッター（瞬間的な波形の乱れ）、%ゆらめき、及び雑音-調音比が含まれており、特にフォルマント分析を重視した。

よく評価の対象となるこれらのパラメータのいずれにも、変化は検出されなかった。これらのパラメータは、患者自身と彼らの友人や家族による主観的な評価と、隔離された音声病学研究室の条件下で各種装置による客観的な評価を受けた。結論として、上顎洞挙上術は、極度に萎縮した上顎臼歯部の再建にとって、安全で、予知性の高い、エビデンスに基づく方法だと思われ、声質が職業上非常に重要である特殊な患者群においても、特徴的な音声パターンを損なうことはないと思われる。

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