

# Hearing changes after temporomandibular joint arthroscopy: a prospective study

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**Abstract.** Temporomandibular Joint (TMJ) arthroscopy is considered an effective and safe minimally invasive surgical approach. While the long-term outcomes of arthroscopy tend to be positive and free of secondary effects, patients occasionally complain about their hearing following the treatment. The aim of this prospective study was to investigate possible hearing changes associated with TMJ arthroscopy. Pure-tone audiograms were performed in patients two weeks before TMJ arthroscopy and repeated six weeks after intervention. A total of 15 patients (mean age of  $41.73 \pm 16.36$ ) were enrolled; 25 TMJ arthroscopies were performed (five unilateral and 10 bilateral). Statistically significant differences were found between preoperative and postoperative audiograms in the frequencies 256 Hz ( $P = 0.011$ ) and 8 kHz ( $P = 0.058$ , borderline). For the frequency 256 Hz the difference was favourable, but not superior to 5 dB. For the frequency 8 kHz, in three patients the TMJ arthroscopy resulted in a decrease of 10 dB. However, no clinical hearing changes or complaints were observed in the involved patients. No differences in audiograms between level 1 or 2 arthroscopy were observed. The study reinforces the safety of the TMJ arthroscopy level 1 and 2 with the reported protocol. The authors recommend larger studies to validate the results, specially for frequency 8 kHz.

**Key words:** prospective studies; temporomandibular joint disorders; minimally invasive surgical procedures; TMJ arthroscopy; audiometry.

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Temporomandibular disorders (TMD) are among the most common causes of orofacial pain<sup>1</sup>. Many studies have reported an association between TMD and otological symptoms such as hypoacusis, hearing loss, tinnitus, earache, vertigo and ear

fullness<sup>2–6</sup>. Temporomandibular joint (TMJ) arthroscopy is a minimally invasive surgical option for intra-articular disorders with good long-term results<sup>7</sup> and is considered a safe procedure<sup>8,9</sup>. During 4 years of regular TMJ arthroscopic practice in

our department, two patients reported subjective hearing changes following the procedure, which was a cause for concern. Available literature on the topic from 1989 did not report any changes in audiograms after TMJ arthroscopy<sup>10</sup>. In the authors'

opinion, there are three potential causes for hearing changes after TMJ arthroscopy: (1) Acoustic trauma, caused by drilling during the operation, could occur if the sound level meter (SLM) exceeded 118 dBA<sup>11</sup> (with variation being associated with drill speeds and different burr types<sup>12</sup>). We were able to exclude this possibility because burrs are not used in TMJ arthroscopy operations carried out in our department, and the coblator ReFlex Ultra with plasma technology does not produce any significant sound or vibration. (2) Acoustic damage caused by the compression of major structures due to extravasation of fluid into surrounding tissues or high intra-articular pressure in arthroscopic surgery (14.883 kPa  $\pm$  0.860). We exclude this as a possible cause, because the noble structures of the ear are enclosed in the otic capsule, surrounded by solid bone. (3) Acoustic damage due to turbulence and vibration associated to fluid lavage. We have accepted this hypothesis, which is supported by the observation that continuous vibration can induce histological cochlear damage<sup>13–15</sup>. In 2013, a computational TMJ fluid dynamics analysis demonstrated that during TMJ arthroscopy the fluid speed in the joint could fall in a range of 0.740 m/s  $\pm$  0.106, substantially higher than in arthrocentesis (0.063 m/s  $\pm$  0.020)<sup>16</sup>. The increased fluid speed during joint lavage could be associated with vortices, turbulence and vibration in the joint, leading to possible hearing damage. This

would probably go unnoticed unless audiometry were performed.

This prospective study aims to evaluate the possible effect of TMJ arthroscopy on the ear, comparing pure-tone audiogram changes before and after surgery.

## Materials and Methods

### Study Design

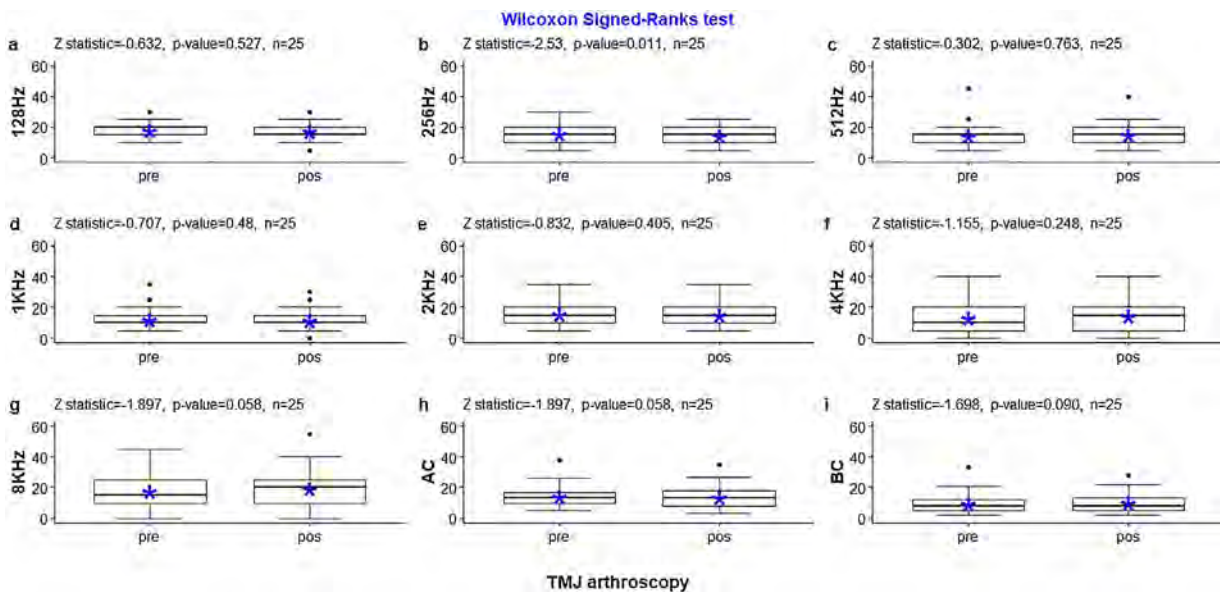
This prospective study was conducted at the Instituto Português da Face, Lisboa, Portugal from January 1, 2019 to December 31, 2019. The study was approved by the ethics committee of *Centro Academico de Medicina de Lisboa*. All enrolled patients gave their informed consent in writing, in accordance with the current legislation. Patient data was scrubbed of any personal identifying parameters and each patient was given a random ID number. The criteria for study inclusion were: (1) age > 18 years; (2) TMD fulfilling the criteria for TMJ arthroscopy; (3) magnetic resonance imaging (MRI) presenting intra-articular pathology. The exclusion criteria were the presence of previous: (1) TMJ surgical intervention; (2) facial trauma; (3) otologic pathology; (4) otologic surgical intervention. An audiology technician performed a pure-tone audiometry on two distinct timelines: 2 weeks preoperative and 6 weeks postoperative. All patients were tested for hearing bilaterally regardless of whether their arthroscopy was unilateral or bilateral. Bilateral arthroscopies were analysed as isolated unilateral arthroscopies. No

distinction was made between left and right sides. No other otological symptoms were accessed.

### Surgical Protocol

All patients underwent general anaesthesia with nasotracheal intubation, managed in most cases using intravenous protocol, usually with remifentanyl and tranexamic acid infusion. Intraoperative steroids, usually dexamethasone, were administered, primarily to minimize postoperative swelling. TMJ arthroscopy was performed with a 1.9-mm arthroscope including a video system (Stryker, San Jose, CA, USA), with a 2.8-mm outer protective cannula. Additional equipment included a surgical scalpel (#11 blade), an infusion tube, a three-way pipe and Ringer solution as part of the armamentarium. For TMJ arthroscopy level 1, the authors used the classic puncture with an entry point 10 mm anterior and 2 mm below the Holmlund–Hellsing (H-H) line. The arthroscope was inserted in a forward and upward direction (15–45°) into the superior joint space. A second puncture with a 21-G needle was performed 30 mm anterior and 7 mm below the H-H line to wash the joint with 250–300 ml Ringer solution. After washing the joint, 1.5–2 cc of hyaluronic acid was injected into it.

For level 2 TMJ arthroscopy, the second puncture was substituted by a 2.8-mm outer protective cannula with sharp trocar until the joint was reached. The 2.8-mm



*Fig. 1.* Box-plots comparing the distributions of the preoperative and postoperative audiogram results (asterisk = mean). On the top, we report Wilcoxon signed-rank test data, namely the Z statistic and corresponding P-value. For a significance level of 5%, there were statistically significant differences in the distribution of the values for frequencies 256 Hz and 8 kHz (borderline).

cannula was used for instrumental passageway for (1) a ReFlex Ultra 45 Plasma Wand system for intra-articular coblation and/or (2) intrasynovial medication through a 22-G long spinal needle. Antibiotic protocol (amoxicillin/clavulanic acid or clarithromycin) and non-steroidal anti-inflammatory drugs (ibuprofen) were routinely prescribed following surgery and the patients were instructed to follow a soft diet for 3 days postoperatively. Mouth opening exercises were started 1 week after surgery.

### Statistical Analysis

Numerical variables were expressed as the mean ( $\pm$ standard deviation) and analysed inferentially using statistical tests. The frequencies studied were: 128 Hz, 256 Hz, 512 Hz, 1 kHz, 2 kHz, 4 kHz and 8 kHz, along with air conduction (AC) and bone conduction (BC). Shapiro–Wilk test was used to determine normality of data. Non-parametric statistics were used given the absence of normality in the distributions under analysis. The Wilcoxon signed-rank test (data with non-normal distribution and symmetrical differences) was performed to compare the distribution of audiogram results before and after surgery, in the search for statistically significant differences between the two groups.

The nonparametric Mann–Whitney *U*-test was used to compare the distributions of audiogram results between levels 1 and 2 arthroscopies. The level of significance

alpha was set at 5%. The statistical analyses were performed using R.

### Results

A total of 15 patients aged between 21 and 70 years, mean age of 41.73 ( $\pm$ 16.36 years) were enrolled. Ten patients underwent bilateral arthroscopy and five patients received unilateral arthroscopy, resulting in a total of 25 operated joints.

Preoperative audiograms were normal for all but two patients. Both of these had had a previous neurosensorial hypoacusis: the first patient was 70 years old (30 dB in right ear and 30 dB in left ear) and the second patient was 59 years old (31.25 dB right ear and 21.25 dB in left ear).

According to Wilcoxon's test in the 15 patients, we observed statistically significant differences ( $P < 0.05$ ) between preoperative and postoperative audiograms in the frequencies 256 Hz ( $P = 0.011$ ) and 8 kHz ( $P = 0.058$ , borderline). None of the patients reported clinical hearing complaints. Fig. 1 shows the detailed results of the Wilcoxon signed-rank test as well as the graphical representation of the percentiles, before and after the surgery. The representation of the mean values for each studied frequency can be seen in Fig. 2.

The nonparametric Mann–Whitney *U*-test concluded there were no statistically significant differences in the distribution of the audiograms results in relation to levels 1 and 2 of the arthroscopies ( $W = 3498$ ,  $P = 0.11$ ).

### Discussion

Pure-tone audiometry consists of the study of the minimal auditive threshold for each frequency. Each threshold corresponds to the minimal intensity in which a sound is heard in at least 50% of the presented sequences for each tested frequency. This exam is a behavioural method to access hearing once it depends on the patient voluntary response when a sound is presented. In this regard, the pure-tone audiogram results do not correspond to an exact value; instead, this corresponds to an approximate estimate value around which the patient can hear the minimum auditive stimulus<sup>17</sup>. Combining this definition with the modified Hugson–Westlake limits method, which is the acquisition technique used, means that hearing thresholds  $\pm 5$  dB should be considered as not different. In the present study, the statistical analysis of the audiograms presented significant differences between pre- and postoperative audiograms in the frequencies 256 Hz ( $P = 0.011$ ) and 8 kHz ( $P = 0.058$ ) (Fig. 1). Nonetheless, the range of the differences in frequency 256 Hz was not superior to 5 dB and was an improvement in hearing. Regarding frequency 8 kHz, we observed differences superior to 5 dB in three patients. Those three patients had a deterioration of 10 dB in the pure-tone audiogram, however none of the patients reported any perceptible hearing impairment. This change in frequency 8 kHz could easily go unnoticed by the patient and/or surgeon. More than a hear-

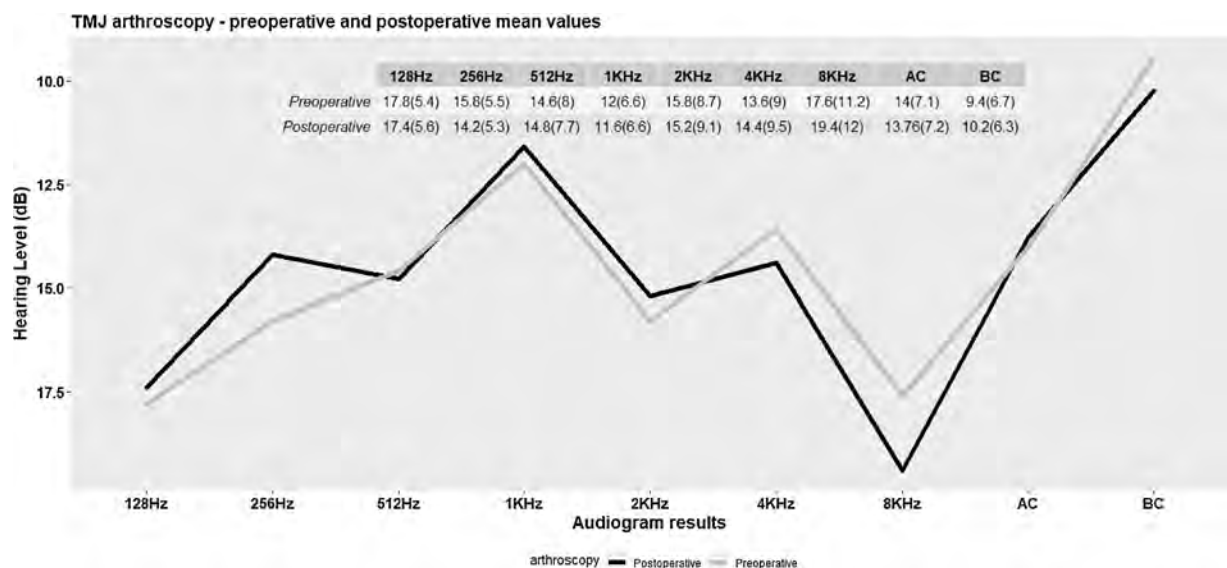


Fig. 2. Representation of the mean values for preoperative (grey line) and postoperative (black line) audiogram results (x-axis). In the y-axis the hearing levels in decibels (dB). The table inside the graph shows these averages with the respective standard deviations in brackets.

ing impairment, it could lead to tinnitus sensation, which was not observed.

McCain et al.<sup>10</sup> and Jerry et al.<sup>18</sup>, reported no changes in hearing levels following TMJ arthroscopic surgery, however no inferentially statistical tests were used for the different frequencies. In the study by McCain et al.<sup>10</sup> the postoperative evaluation was performed 4 weeks after intervention, in Jerry et al.<sup>18</sup> after 48 h, while in our study it was performed 6 weeks after.

We did not observe any differences in audiograms between single or double puncture. Moreover, no data has been reported in the literature regarding this topic.

Concerning the possible non-surgical causes of hearing changes, most are outside the scope of TMJ surgeons, as they are generally related to epidural anaesthesia<sup>19,20</sup> or cardiopulmonary bypass surgery<sup>21</sup>. However, prior to 2009, a total of 52 cases of hearing loss following non-otological surgery with general anaesthesia were reported<sup>22</sup>. Rare cases were associated with maxillofacial procedures; however, we found one report related to hearing loss following bilateral TMJ arthroscopy<sup>23</sup>. In this specific case, the anaesthesia protocol included nitrous oxide, and the cause was attributed to this toxic gas. Nitrous oxide is 30 times more soluble in blood than nitrogen. Therefore, nitrous oxide penetrates the middle ear faster than nitrogen is expelled, resulting in increased middle ear pressure, which leads to barotrauma. One case of idiopathic hearing loss after a forehead lift was reported<sup>24</sup>; this continues to be a difficult situation to manage, especially in cosmetic surgery. In 1991, four cases of sudden deafness following dental surgery were reported (one using general anaesthesia and three using local anaesthesia), but no explanation has been given to account for this deafness<sup>25</sup>. The cause of hearing loss following general anaesthesia remains unknown. A variety of potential causes have been suggested, including changes in middle ear pressure, cerebrospinal fluid pressure change, vascular disease, embolism, ototoxic drugs, and other miscellaneous issues<sup>26</sup>.

While most studies consider TMJ arthroscopy a safe procedure, the majority are limited to the observation of intra- or immediate postoperative complications, and given the fact that hearing impairment is often subclinical, it can easily go unnoticed unless audiometry is performed<sup>20,27</sup>. With this prospective study, the authors intended to clarify possible ear changes following TMJ arthroscopy.

The limitations of this study were: (1) the small sample size; (2) the 6-week follow-up audiogram – for future studies it may be helpful to observe changes in more timelines (the authors suggest 3 days, 2 weeks, 4 weeks and 6 weeks postoperatively); (3) the conventional pure-tone audiometry was performed analysing frequencies from 128 Hz to 8 kHz. An extended high-frequency audiometry which evaluates hearing thresholds at frequencies higher than 8 kHz (i.e. 10, 12, 14, 16, 18 and 20 kHz) could present new results; (4) the hypothesis that turbulence and vibration are associated with fluid velocity was not tested or confirmed; (5) no otoscopy was performed; (6) no other otological symptoms were accessed.

In summary, in this study the authors observed statistically significant differences for frequencies 256 Hz (hearing improvement) and 8 kHz (hearing impairment) between preoperative and postoperative audiograms, however no clinical changes were observed. No differences were found for level 1 and 2 TMJ arthroscopy ( $P = 0.11$ ).

Larger studies are recommended (with other otological assessments, if possible) to allow for clinical hearing changes assessments. Regular audiometry tests for older patients could be adopted as a preventive measure, as those patients may be more likely to experience subclinical changes at higher frequencies (4 kHz and 8 kHz).

### Competing interests

The authors have no conflicts of interest to declare.

### Funding

Not applicable.

### Ethical approval

This study was approved by the ethics committee of *Centro Académico de Medicina de Lisboa*.

### Patient consent

All the enrolled participants gave their informed, clarified and free term of consent in writing and in accordance with current legislation.

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ijom.2021.02.013>.

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