Oral and Maxillofacial Surgery (2024) 28:1127–1138
https://doi.org/10.1007/s10006-024-01232-3

RESEARCH

# Risk factor analysis for perioperative complications in impacted third molar surgery – a single center experience

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Received: 11 January 2024 / Accepted: 25 February 2024 / Published online: 1 March 2024


## Abstract

**Background** The surgical removal of impacted third molars is usually carried out by an oral/maxillofacial surgeon. Two specific risks of surgical removal of impacted third molars are oroantral communication (OAC) when extracting upper third molars and hypesthesia of the inferior alveolar nerve (IAN) when extracting lower third molars. The aim of this study is to determine the distribution of complications in deeply impacted third molar surgery, to identify specific risk factors influencing the most common perioperative (OAC, IAN hypesthesia) and to compare these results with other studies.

**Materials and methods** The clinical findings, digital panoramic radiographs, intra- and postoperative data of 80 patients with a total of 232 impacted third molars that had been subjected for tooth extraction, from December 2022 and August 2023, were collected and analyzed. Perioperative complications (IAN hypesthesia, OAC, hypesthesia lingual nerve, postoperative bleeding, postoperative infection) were identified. A risk analysis for OAC and IAN hypesthesia was performed regarding perioperative data.

**Results** Overall, the rate of OAC for the right upper third molar was 12.8% and for the left upper third molar 15.6%. The complication rates regarding transient hypesthesia were 8.1% for the left IAN and 7.3% for the right IAN. The distance to maxillary sinus, the depth score according to Pell and Gregory, the bone coverage score, the operation time, the tooth's angulation and the type of surgeon (oral surgeon, DMD) were identified as significant risk factors for the occurrence of OAC. The minimum distance to IAN, the bone coverage score, the total operation time and the operation by an oral surgeon (DMD) were identified as significant risk factors for hypesthesia of the IAN.

**Conclusion** Next to the risk factors from above, the present study is one of the first showing that patients who were primarily operated on by an oral surgeon (DMD) and not a maxillofacial surgeon (MD, DMD) showed higher rates of OAC and IAN hypesthesia in impacted third molar extraction. The results of this study can serve as a baseline for further studies to investigate complication patterns in impacted third molar surgery.

**Keywords** Impacted third molars · Perioperative complications · Risk analysis

## Introduction

The prevalence of third molars varies among different populations [1, 2]. Studies have identified prevalence of third molar agenesis rising up to 40% [3]. The clinical manifestations of third molars can be complex. Third molars can show a normal tooth eruption causing no symptoms or can also show eruption problems [4].

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The result of a disturbed tooth eruption of the third molars is usually impacted and sometimes additionally displaced/angulated third molars. The causes of an impaction of the third molars can be diverse [4]. Depending on the clinical and radiological findings, both erupted and impacted third molars may have an indication for surgical molar removal. Examples of indications for extraction of third molars include infections, orthodontic and occlusion problems, deeply decayed third molars or cystic changes originating from the third molars [5].

The surgical removal of third molars is considered a standard procedure in both practices and outpatient clinics. Molars that have erupted and are settled in occlusion are often removed by an oral surgeon and/or general dentist.

As soon as the teeth are impacted, surgical molar removal is often carried out by a specialized oral/maxillofacial surgeon, sometimes under inpatient conditions. The prevalence of impacted third molars also varies among different populations and is up to 50% [6, 7].

The surgical removal of deeply impacted third molars is usually carried out by an experienced maxillofacial surgeon due to the increased risk of perioperative complications. In addition to the general risks (bleeding, infection), the specific risks of surgical removal of impacted third molars are oroantral communication (OAC) in the area of the upper third molars and hypesthesia of the inferior alveolar nerve (IAN) resulting from an intraoperative nerve damage in the area of the lower third molars or the lingual nerve [8]. The rates of perioperative complications for OAC vary between 5.1% and 24% depending on the study and degree of impaction of the upper molars [9, 10].

With regards to transient and/or permanent hypesthesia in the area of the IAN, the rates for this form of complication vary between 0.35—8.4% (in younger patients up to 9.8%) [11, 12]. Hypesthesia of the lingual nerve is a very rare complication of this procedure, with rates of up to 2.6% [12]. Postoperative bleeding can occur after tooth extraction with rates up to 1.5% [8]. The risk for postoperative bleeding after dental extraction increases when people are treated with antithrombotic medications [13]. The rates of postoperative infections of the head and neck region following this operation are up to 5.5% and mainly occur within the first postoperative days [14, 15].

There is currently a lot of data and studies regarding the impaction patterns of third molars as well as different scoring systems such as the difficulty scale according to Gordon and Pederson for third molar extraction [1, 16, 17]. However, various studies have shown that this score is not valid or practical for all third molar extractions [16]. Up to date there is no comprehensive and particularly reliable risk analysis of the complication rates (e.g. OAC and IAN) for the removal of all impacted third molars [16].

The aim of this retrospective study is to determine the distribution of complications in deeply impacted third molar extraction in a sample of a (Nothern-)German population treated in the Department of Oral and Maxillofacial Surgery at the Army Hospital Hamburg (high turnover maxillofacial clinic). Furthermore, this study aims to identify specific risk factors (e.g. impaction patterns, angulations, bone coverage, distance scores) influencing the most common perioperative complications in deeply impacted third molar surgery (OAC, IAN hypesthesia) in order to predict possible complications for future patients receiving this type of surgery.

## Materials and methods

### Data collection

This retrospective study examined patients with impacted third molars who were operated in the Department of Oral and Maxillofacial Surgery between December 2022 and August 2023. At least one third molar was extracted from each patient in the study. All patients included in the study had impacted (e.g. partially or completely impacted) third molars with a clear indication for surgical extraction. The extractions were carried out under both outpatient and inpatient conditions. The operations were performed under local anesthesia by experienced oral and/or maxillofacial surgeons (> 2 years of experience, > 400 extractions of impacted third molars). All patients were at least 18 years old and fully capable of consenting to the procedure. Exclusion criteria were incomplete documentation (patient records), elongated third molars, extractions under general anesthesia and poor-quality panoramic radiographs. The baseline characteristics such as gender, age, reason for the extraction of the third molars as well as previous illnesses and medications were retrospectively identified for each patient. Furthermore, a retrospective analysis of the preoperative panoramic radiographs was carried out. Perioperative complications (hypesthesia inferior alveolar nerve, oroantral communication, hypesthesia lingual nerve, postoperative bleeding, postoperative infection) were identified. A total of 80 patients with a total of 232 wisdom teeth were included in the present study.

### Radiographic analysis

The analysis of the panoramic radiographs was carried out using the digitally available data from the Visage 7 Client (7.1.17) program. Angle calculations and distance measurements were performed. The analysis and documentation of the panoramic radiographs was carried out by the first author (experienced maxillofacial surgeon).

### Winter´s classification angle

Based on the analysis of the digital panoramic radiographs, an angle determination was made using two lines (long axis of second and third molars). Therefore, every impacted third molar could be classified according to Winter's classification.

### Pell and Gregory impaction depth

The bone impaction of the teeth was carried out using the Pell and Gregory classification/scoring system (A, B, C).

The classification was based on the distance measurement between the occlusal plane (occlusal surface of two first molars) to the highest occlusal point of the third molar and the depth to the cervical line of the second molar.

### Relationship to Ramus mandibulae

A classification of the relationship to ramus of third molars was also performed. This classification was based on the relation of the third molar crown size (distance mesial + distal) and the distance from the end of the external oblique ridge to the most external distal point of the second molar.

### Bone coverage upper and lower third molars

We also performed an analysis of the bone coverage in the upper and lower jaw. This was divided into deep (>3mm), medium (1—3 mm), superficial (<1 mm) and none. Furthermore, the exact bone coverage was determined for each third molar.

### Distance to maxillary sinus

Using the panoramic radiographs, the smallest distance from the root tips of the upper third molars to the maxillary sinus was measured. Furthermore, a new classification score was used regarding the distance to the maxillary sinus with none, low (<1 mm), medium (1—3 mm) and far (> 3 mm) distance.

### Distance to inferior alveolar nerve

As part of the risk analysis regarding potential nerve damage to the IAN, the smallest distance from the root tip of the lower third molar to the inferior alveolar nerve was measured. In addition, a new classification score of this distance was used regarding none, low (< 1 mm), medium (1—2 mm) and far (> 2 mm) distance to the IAN.

### Risk scale Gordon and Pederson

In addition, a risk analysis was carried out to predict the difficulty of surgical extraction of impacted molars using the Gordon and Pederson scale. A classification into low, medium and high difficulty could be made based on this scoring system.

### Risk factor analysis regarding OAC and IAN hypesthesia

In addition to the general analysis of the population regarding impaction patterns of third molars a risk factor analysis for OAC and IAN hypesthesia for the respective teeth was performed.

**Table 1** Percent distribution of examined patients ($n$ = 80)

| Variable | No. | Percent (%) |
|---|---|---|
| Age (years) | 26.28 ± 7.09 | |
| 10—20 | 8 | 10.0 |
| 20—30 | 53 | 66.3 |
| 30—40 | 16 | 20.0 |
| 40—50 | 2 | 2.5 |
| 50—60 | 1 | 1.3 |
| Gender | | |
| Male | 58 | 72.5 |
| Female | 22 | 27.5 |

**Table 2** Baseline characteristics

| Variable | No. | Percent (%) |
|---|---|---|
| Preexisting Diseases | 9 | 11.3 |
| Medications | 5 | 6.3 |
| Indication for operation/complaint | | |
| Pain | 54 | 67.5 |
| Infection | 15 | 18.8 |
| Orthodontics | 29 | 36.3 |
| Prosthetics | 4 | 5.0 |
| Before Deployment | 5 | 6.3 |

### Statistical analysis

Descriptive analysis was used to display patients baseline characteristics. Normally distributed continuous variables are presented as mean ± standard deviation and binary variables are using absolute and relative frequencies. Comparison of continuous variables was performed by student's t-test. Chi- square test was used for analysis of binary variables. A p-value < 0.05 was considered statistically significant. All statistical analyses were performed using the SPSS version 28.0 statistical package (IMB, Markham, Canada).

## Results

A total of 80 patients were included in the study, of which 58 patients were male and 22 patients were female. The mean age of the patients was 26.28 years. The distribution based on age groups showed a majority of all study participants in the age group between 20 and 30 years (Table 1). The total number of all extracted teeth in the present study was 232 (Table 3). A total of 56 upper right third molars, 53 upper left third molars, 60 lower left third molars and 63

**Table 3** Distribution of examined molars by angulation types according to Winter classification

| Tooth Nb | 18 ($n = 56$) | 28 ($n = 53$) | 38 ($n = 60$) | 48 ($n = 63$) | Total ($n = 232$) |
|---|---|---|---|---|---|
| Mesio-angulated | 16 (28.6) | 13 (24.5) | 19 (31.7) | 25 (39.7) | 73 (31.5) |
| Disto-angulated | 13 (23.2) | 11 (20.8) | 14 (23.3) | 15 (23.8) | 53 (22.8) |
| Horizontal | 0 (0) | 1 (1.9) | 19 (31.7) | 17 (27.0) | 37 (15.9) |
| Vertical | 27 (48.2) | 28 (52.8) | 8 (13.3) | 6 (9.5) | 69 (29.8) |

**Table 4** Distribution of examined molars by depth according to Pell and Gregory classification

| Tooth Nb | 18 ($n = 56$) | 28 ($n = 53$) | 38 ($n = 60$) | 48 ($n = 63$) | Total ($n = 232$) |
|---|---|---|---|---|---|
| Depth | | | | | |
| A | 9 (16.1) | 8 (15.1) | 14 (23.3) | 11 (17.5) | 42 (18.1) |
| B | 19 (33.9) | 11 (20.8) | 26 (43.3) | 34 (54.0) | 90 (38.8) |
| C | 28 (50.0) | 34 (64.1) | 20 (33.3) | 18 (28.5) | 100 (43.1) |

lower right third molars were surgically extracted (Table 3). 9 study participants had previous illnesses (Table 2). The most common indication for the extraction of impacted third molars was pain ($n = 54$), followed by orthodontics ($n = 29$), infection ($n = 15$), before deployment ($n = 5$) and prosthetics ($n = 4$) (Table 2). The angulation types according to Winter's classification of impacted third molars most often showed mesio-angulation (31.5%), followed by vertical angulation (29.8%), disto-angulation (22.8%) and horizontal angulation (15.9%) in relation to the entire study population (Table 3).

Tooth 18 most frequently showed vertical angulation (48.2%), followed by mesio-angulation (28.6%) (Table 3). The same was seen in the angulation of tooth 28 (Table 3). The lower third molars most often showed mesio-angulation (38 = 31.7%; 48 = 39.7%) followed by horizontal angulation (38 = 31.7%; 48 = 27.0%). Vertical angulation was lowest in the lower third molars (38 = 13.3%; 48 = 9.5%) (Table 3). Tooth 18 most frequently showed vertical angulation (48.2%), followed by mesio-angulation (28.6%) (Table 3). The same was found in the angulation of tooth 28 (Table 3). The lower third molars most often showed mesio-angulation (38 = 31.7%; 48 = 39.7%) followed by horizontal angulation (38 = 31.7%; 48 = 27.0%). Vertical angulation was lowest in the lower third molars (38 = 13.3%; 48 = 9.5%) (Table 3).

The analysis of the depth according to Pell and Gregory for the respective impacted third molars revealed a proportion of 43.1% of impacted third molars in class C, 38.8% in class B and 18.1% in class A for the entire study population (Table 4). Upper third molars showed the highest percentage of class C (18 = 50.0%; 28 = 64.1%), whereas lower third molars showed class B as most common depth (38 = 43.3%; 48 = 54.0%) (Table 4).

Furthermore, the analysis of the relationship to ramus mandibulae of lower third molars showed class II as most often for the whole population (54.5%), followed by class I (35.0%) and class III (10.5%) (Table 8). There were no side-specific differences (Table 8).

The bone coverage of the impacted teeth was higher in the lower third molars than in the upper third molars (18 = 1.01 ± 0.92 mm; 28 = 1.21 ± 1.03 mm; 38 = 1.29 ± 1.31 mm; 48 = 2.54 ± 10.53 mm) (Table 5). The classification based on the bone coverage score showed medium bone coverage (1 – 3 mm) to be the most common for the entire population (45.7%) (Table 5). The percentage frequencies for all impacted third molars were similar with no side-specific differences (Table 5).

With regard to the analysis of complications (OAC, IAN damage), an additional analysis of the distance of the upper third molars to the maxillary sinus and the lower third molars to the IAN was carried out (Tables 6 and 7). A total of 33.0% of all upper third molars showed a close relationship between the apical root sections and the maxillary sinus (Table 6). The mean minimum distance was 1.43 ± 1.30 mm for tooth 18 and 1.25 ± 1.19 mm for tooth 28 (Table 6). Regarding the nerve proximity to the IAN, 85.4% of all

**Table 5** Distribution of bone coverage

| Tooth Nb | 18 ($n = 56$) | 28 ($n = 53$) | 38 ($n = 60$) | 48 ($n = 63$) | Total ($n = 232$) |
|---|---|---|---|---|---|
| Mean Bone Coverage +—SD (mm) | 1.01 ± 0.92 | 1.21 ± 1.03 | 1.29 ± 1,31 | 2.54 ± 10.53 | |
| Bone Coverage | | | | | |
| None | 9 (16.1) | 7 (13.2) | 3 (5.0) | 5 (7.9) | 24 (10.3) |
| Superficial (< 1 mm) | 23 (41.1) | 19 (35.8) | 26 (43.3) | 26 (41.2) | 94 (40.5) |
| Medium (1–3 mm) | 23 (41.1) | 23 (43.4) | 29 (48.3) | 31 (49.3) | 106 (45.7) |
| Deep (> 3 mm) | 1 (1.7) | 4 (7.6) | 2 (3.4) | 1 (1.6) | 8 (3.4) |

**Table 6** Maxillary third molars

| Tooth Nb | 18 (n = 56) | 28 (n = 53) | Total (n = 109) |
|---|---|---|---|
| Marginal to maxillary sinus | 20 (35.7) | 16 (30.2) | 36 (33.0) |
| Mean min. Distance to maxillary sinus ± SD (mm) | 1.43 ± 1,30 | 1.25 ± 1.19 | |

**Table 7** Mandible third molars

| Tooth Nb | 38 (n = 60) | 48 (n = 63) | Total (n = 123) |
|---|---|---|---|
| Marginal to inferior alveolar nerve | 51 (85.0) | 54 (85.7) | 105 (85.4) |
| Mean min. Distance to inferior alveolar nerve ± SD (mm) | 0.85 ± 0.89 | 0.87 ± 0.83 | |

**Table 8** Distribution of examined molars by relationship to ramus mandibulae

| Tooth Nb | 38 (n = 60) | 48 (n = 63) | Total (n = 123) |
|---|---|---|---|
| Relationship to Ramus mandibulae | | | |
| I | 20 (33.3) | 23 (36.5) | 43 (35.0) |
| II | 34 (56.7) | 33 (52.4) | 67 (54.5) |
| III | 6 (10.0) | 7 (11.1) | 13 (10.5) |

**Table 9** Risk Scale according to Gordon and Pederson scale for scoring predictive difficulty of surgical extraction (low = 3—4, medium = 5—9, high = 7—10)

| Tooth Nb | 18 (n = 56) | 28 (n = 53) | 38 (n = 60) | 48 (n = 63) | Total (n = 232) |
|---|---|---|---|---|---|
| Risk Score | | | | | |
| Low | 29 (51.8) | 22 (41.5) | 7 (11.7) | 7 (11.1) | 65 (28.0) |
| Medium | 24 (42.9) | 24 (45.3) | 32 (53.3) | 36 (57.1) | 116 (50.0) |
| High | 3 (5.3) | 7 (13.2) | 21 (35.0) | 20 (31.8) | 51 (22.0) |

lower third molars showed a close relationship to IAN with a mean minimum distance of 0.85 ± 0.89 mm for tooth 38 and 0.87 ± 0.83 mm for tooth 48 (Tables 7 and 8).

Difficulty score calculation according to Gordon and Pederson revealed medium difficulty as most common score (50.0%) (Table 9). Lower third molars revealed the highest percentage for high difficulty extraction scores (38 = 35.0%; 48 = 31.8%) according to Gordon and Pederson (Table 9). A total of 14 patients developed an intraoperative OAC when extracting tooth 18 and 17 patients when extracting tooth 28 (Table 10). 8.1% of the patients showed a transient hypesthesia of the left IAN, as well as 7.3% for the right IAN (Table 10). All hypesthesia was only transient and disappeared throughout the follow up. At the time of follow-up (suture removal after 12 days), all hypesthesia had subsided with no remaining sensory deficit. There was no postoperative bleeding nor infection in the present study (Table 10). Furthermore, no hypesthesia of the lingual nerve was seen (Table 10).

**Table 10** Perioperative complications (Percentage)

| Variable | Total (Percentage) |
|---|---|
| Oroantral communication | 31 (28.4) |
| Oroantral communication – tooth 18 | 14 (12.8) |
| Oroantral communication – tooth 28 | 17 (15.6) |
| Hypesthesia IAN | 19 (15.4) |
| Hypesthesia IAN left | 10 (8.1) |
| Hypesthesia IAN right | 9 (7.3) |
| Hypesthesia LN | 0 (0) |
| Bleeding postoperative | 0 (0) |
| Infection postoperative | 0 (0) |

In addition to that, a specific risk analysis regarding OAC was carried out for the two upper third molars. Regarding the occurence of OAC for tooth 18, there were highly significant differences with regard to the previously developed distance score of tooth 18 to the maxillary sinus (Table 11). Patients with OAC on the right side had significantly smaller preoperative distances (none, low) in relation to the maxillary sinus than patients without OAC. Furthermore, patients with OAC on the right side showed significantly higher depth scores according to Pell and Gregory for tooth 18 compared to patients without OAC (Table 11). This is accompanied by significantly higher bone coverage distances (OAC tooth 18 = 1.44 ± 0.96 mm, No OAC tooth 18 = 0.86 ± 0.87 mm) and bone coverage scores of tooth 18 with OAC as well as increased difficulty extraction scores for tooth 18 in comparison to patients without OAC after extraction of tooth 18 (Table 11). Furthermore, the operation time was significantly higher in patients with OAC compared to patients without OAC after extraction of tooth 18 (Table 11).

The risk factor analysis for the development of OAC during the extraction of tooth 28 showed highly significant differences in comparison with patients without OAC after extraction of the impacted tooth 28 with regards to the angulation of tooth 28 according to Winter´s classification (Table 12). Patients with OAC had significantly higher distal- and mesio-angulations (35.3%; 29. 4%) than patients without OAC (Table 12). At the same time, patients without OAC showed significantly higher proportions of vertically angled teeth 28 (Table 12). Significant differences were also found for the distance score of tooth 28 towards the maxillary sinus regarding OAC/ no OAC, with significantly increased proportions of a none to low distance score (OAC

**Table 11** Analysis of risk factors for oroantral communication upper right third molar (tooth 18)

| Variable | OAC ($n = 14$) | No OAC ($n = 42$) | $p$-Value |
|---|---|---|---|
| Preexisting Disease | 2 (14.3) | 7 (16.6) | 0,620 |
| Medication | 2 (14.3) | 3 (7.1) | 0,171 |
| Operation under general anesthesia | 4 (28.6) | 13 (31.0) | 0,461 |
| Indication for operation/complaint | | | |
| Pain | 9 (64.3) | | 0,871 |
| Infection | 2 (14.3) | 13 (31.0) | 0,638 |
| Orthodontics | 6 (42.8) | 25 (59.5) | 0,089 |
| Prosthetics | 0 (0) | 2 (4.8) | 0,345 |
| Before Deployment | 1 (7.1) | 2 (4.8) | 0,879 |
| Marginal to maxillary sinus—Upper third molars | 9 (64.3) | 27 (64.3) | 0,648 |
| Angulation Types 18 | | | 0,085 |
| Mesio-angulated | 4 (28.6) | 12 (28.6) | |
| Disto-angulated | 4 (28.6) | 9 (21.4) | |
| Horizontal | 0 | 0 (0) | |
| Vertical | 6 (42.8) | 21 (50.0) | |
| Distance rg 18 maxillary sinus score | | | **0,004** |
| None | 1 (7.1) | 0 (0) | |
| Low (< 1 mm) | 8 (57.1) | 15 (35.7) | |
| Medium (1—3 mm) | 3 (21.4) | 19 (45.2) | |
| Far (> 3 mm) | 2 (14.3) | 8 (19.1) | |
| Depth—tooth 18 | | | **0,044** |
| A | 2 (14.3) | 8 (19.1) | |
| B | 4 (28.6) | 14 (33.3) | |
| C | 8 (57.1) | 20 (47.6) | |
| Bone Coverage—tooth 18 | | | **0,003** |
| None | 1 (7.1) | 8 (19.1) | |
| Superficial (< 1 mm) | 3 (21.4) | 20 (47.6) | |
| Medium (1—3 mm) | 9 (64.3) | 14 (33.3) | |
| Deep (> 3 mm) | 1 (7.1) | 0 (0) | |
| Age > 26 | 7 (50.0) | 28 (66.7) | 0,604 |
| Risk Score—tooth 18 | | | **0,014** |
| Low | 5 (35.7) | 24 (57.1) | |
| Medium | 8 (57.1) | 16 (38.1) | |
| High | 1 (7.1) | 2 (4.8) | |
| Mean min. Distance to maxillary sinus ± SD (mm)—tooth 18 | 1.06 ± 1.33 | 1.57 ± 1.28 | 0,207 |
| Mean Bone Coverage ± SD (mm)—tooth 18 | 1.44 ± 0.96 | 0.86 ± 0.87 | **0,039** |
| Mean Risk Scale ± SD—tooth 18 | 5.14 ± 1.03 | 4.49 ± 1.21 | 0,075 |
| Gingivaplastic | 14 (100.0) | 32 (76.2) | **< 0,001** |
| Operation Time in minutes | 67.50 ± 27.79 | 47.50 ± 23.59 | **0,007** |
| Time per Tooth in minutes | 19.38 ± 5.82 | 17.83 ± 6.30 | 0,401 |
| CMFS | 5 (35.7) | 38 (90.5) | 0,136 |

**Table 12** Analysis of risk factors for oroantral communication upper left third molar (tooth 28)

| Variable | OAC ($n = 17$) | No OAC ($n = 36$) | $p$-Value |
|---|---|---|---|
| Preexisting Disease | 4 (23.5) | 5 (13.9) | 0,055 |
| Medication | 2 (11.8) | 3 (8.3) | 0,290 |
| Operation under general anesthesia | 5 (29.4) | 12 (33.3) | 0,354 |
| Indication for operation/complaint | | | |
| Pain | 12 (70.6) | 24 (66.7) | 0,821 |
| Infection | 3 (17.6) | 12 (33.3) | 0,896 |
| Orthodontics | 8 (47.1) | 21 (58.3) | 0,458 |
| Prosthetics | 0 (0) | 4 (11.1) | 0,286 |
| Before Deployment | 1 (5.9) | 4 (11.1) | 0,944 |
| Marginal to maxillary sinus—Upper third molars | 10 (58.9) | 26 (72.2) | 0,985 |
| Angulation Types 28 | | | **0,002** |
| Mesio-angulated | 5 (29.4) | 8 (22.2) | |
| Disto-angulated | 6 (35.3) | 5 (13.8) | |
| Horizontal | 0 (0) | 1 (2.8) | |
| Vertical | 6 (35.3) | 22 (61.1) | |
| Distance rg 28 maxillary sinus score | | | **0,023** |
| None | 1 (5.9) | 3 (8.3) | |
| Low (< 1 mm) | 8 (47.1) | 12 (33.3) | |
| Medium (1—3 mm) | 7 (41.1) | 18 (50.0) | |
| Far (> 3 mm) | 1 (5.9) | 3 (8.3) | |
| Depth—tooth 28 | | | **0,017** |
| A | 1 (5.9) | 7 (19.4) | |
| B | 5 (29.4) | 6 (16.7) | |
| C | 11 (64.7) | 23 (63.9) | |
| Bone Coverage—tooth 28 | | | **< 0,001** |
| None | 2 (11.8) | 5 (13.8) | |
| Superficial (< 1 mm) | 3 (17.6) | 16 (44.4) | |
| Medium (1—3 mm) | 10 (58.8) | 13 (36.2) | |
| Deep (> 3 mm) | 2 (11.8) | 2 (5.6) | |
| Age > 26 | 6 (35.3) | 29 (80.6) | 0,428 |
| Risk Score—tooth 28 | | | **0,003** |
| Low | 6 (35.3) | 16 (44.4) | |
| Medium | 7 (41.1) | 17 (47.3) | |
| High | 4 (23.6) | 3 (8.3) | |
| Mean min. Distance to maxillary sinus ± SD (mm)—tooth 28 | 1.17 ± 1.22 | 1.29 ± 1.18 | 0,724 |
| Mean Bone Coverage ± SD (mm)—tooth 28 | 1.54 ± 1.16 | 1.07 ± 0.94 | 0,130 |
| Mean Risk Scale ± SD—tooth 28 | 5.41 ± 1.33 | 4.89 ± 1.17 | 0,151 |
| Gingivaplastic | 17 (100.0) | 29 (80.6) | **< 0,001** |
| Operation Time in minutes | 61.47 ± 26.38 | 48.38 ± 24.53 | 0,058 |
| Time per Tooth in minutes | 19.09 ± 6.00 | 17.83 ± 6.28 | 0,461 |
| CMFS | 5 (29.4) | 30 (83.3) | **0,023** |

tooth 28 = 53%; No OAC tooth 28 = 41.6%) in patients with OAC after extraction of tooth 28 (Table 12). Significantly higher depth scores were also found in patients with OAC after extraction of tooth 28 in comparison with patients that did not show OAC. The bone coverage score was also significantly increased in patients with OAC compared to patients without OAC (Table 12). Furthermore, patients with OAC of tooth 28 showed significantly increased extraction difficulty scores according to Gordon and Pederson (Table 12). In addition to that, patients who had tooth 28 extracted by a maxillofacial surgeon instead of an oral surgeon showed significantly lower numbers of OAC (Table 12).

The risk factor analysis for IAN hypesthesia of tooth 38 showed significant differences regarding the minimum distance of the most apical root tip of tooth 38 to the IAN (Table 13). Patients with hypesthesia showed significantly smaller distances (0.33 ± 0.50 mm) compared to patients without hypesthesia (0.94 ± 0.91 mm) regarding the left IAN. Furthermore, patients with a left hypesthesia showed significantly higher bone coverage values (2.43 ± 2.43 mm) compared to patients without hypesthesia (1.08 ± 0.90 mm). Patients with a hypesthesia also showed a significantly higher operation time as well as time per extracted tooth (23.93 ± 4.83 min) compared to patients without hypesthesia (17.34 ± 5.97 min). In analogy to OAC for tooth 28, patients without hypesthesia were significantly more often operated by maxillofacial surgeons (Table 13).

Patients with hypesthesia after extraction of the impacted lower third molar on the right were significantly less likely to be operated on by a maxillofacial surgeon (Table 14). Furthermore, patients with hypesthesia on the right IAN (68.33 ± 23.98 min) had significantly higher total operation times than patients without right IAN damage (48.99 ± 24.83 min) (Table 14). There were no significant differences regarding the teeth´s depth according to Pell and Gregory, the angulation according to Winter nor the bone coverage of tooth 48 regarding postoperative hypesthesia on the right IAN (Table 14).

## Discussion

The surgical removal of impacted third molars is one of the standard procedures in a practice and/or clinic for oral and maxillofacial surgery. In addition to infections and bleeding, the specific surgical risks include the risk of transient/permanent hypesthesia in the area of the IAN as well as the development of OAC in impacted third molars. The present study examined the complication rates after the removal of only impacted third molars in a total of 80 patients ($n$ = 232). The majority of affected third molars were moderate to severe impacted according to molars' depth scores as well as bone coverage scores. In the context of other scientific work that examined perioperative complication rates, both the population size and the number of extracted teeth in the present monocentric study allow for comparability [9, 10, 18].

In the present study, no study participant showed postoperative hypesthesia of the lingual nerve. Furthermore, there were no postoperative bleedings and/or postoperative infections. Here, the available data showed significantly lower rates of postoperative infections than comparable studies from Kuwait and Japan [14, 19]. Furthermore, Miclotte et al. showed higher rates of postoperative bleeding, which, however, were primarily due to suboptimal management of antithrombotic drugs [20]. The rates of postoperative bleeding during the extraction of impacted third molars is generally considered to be low (0.2%—1.5%) [8]. However, the present study was able to even lower these complication rates (0%). Regarding the primary endpoints (OAC and IAN hypesthesia), there were slightly increased rates of OAC compared to IAN hypesthesia (Table 10). Overall, the rate of OAC for the right upper third molar was 12.8% and for the left upper third molar 15.6%. The number of OAC in the present study seems to be in the middle range of OAC rates already described in comparable studies from Europe [9, 10]. With regard to the risk factor analysis regarding OAC for tooth 18, there were significant differences to the distance of the maxillary sinus, the depth score according to Pell and Gregory, the bone coverage score and the operation time for the occurrence of this complication.

The risk factor analysis regarding OAC for tooth 28 showed significant differences with regards to the tooth's angulation, the distance to maxillary sinus, the depth according to Pell and Gregory, the bone coverage score, the difficulty score according to Gordon and Pederson, and the type of surgeon. Patients operated on by an oral surgeon (DMD) showed higher rates of OAC than patients operated on by a maxillofacial surgeon (MD, DMD). The cited study from Spain was also able to identify the depth of the upper third molars as risk factors for the complication of OAC [10]. Furthermore, the complexity of the surgical technique and the performance of an ostectomy were described as risk factors [10]. The operation time, the distance to maxillary sinus and the bone coverage were not fully examined nor identified as risk factors. The study by Rothamel et al. from Germany showed that the risk of OAC increases significantly with intraoperative root fractures, a higher degree of impaction and an increased age [9].

The operation time, the angulation of the upper third molars, and the difficulty score could not be identified/examined as risk factors for the occurrence of OAC in their study. The present study is one of the first showing that patients who were primarily operated on by an oral surgeon (DMD) and not a maxillofacial surgeon (MD, DMD) showed higher rates of OAC. Handelman et al. was unable to find

**Table 13** Analysis of Risk Factors for hypesthesia in the left inferior alveolar nerve (tooth 38)

| Variable | Hypesthesia ($n = 10$) | No Hypesthesia ($n = 50$) | $p$-Value |
|---|---|---|---|
| Preexisting Disease | 2 (20.0) | 7 (14.0) | 0,286 |
| Medication | 2 (20.0) | 3 (6.0) | 0,057 |
| Operation under general anesthesia | 4 (40.0) | 13 (26.0) | 0,128 |
| Indication for operation/complaint | | | |
| Pain | 10 (100.0) | 44 (88.0) | 0,060 |
| Infection | 4 (40.0) | 11 (22.0) | 0,070 |
| Orthodontics | 4 (40.0) | 24 (48.0) | 0,863 |
| Prosthetics | 0 (0) | 4 (8.0) | 0,435 |
| Before Deployment | 0 (0) | 5 (10.0) | 0,379 |
| Marginal to IAN—tooth 38 | 9 (90.0) | 42 (84.0) | 0,121 |
| Angulation Types 38 | | | 0,249 |
| Mesio-angulated | 5 (50.0) | 14 (28.0) | |
| Disto-angulated | 0 (0) | 14 (28.0) | |
| Horizontal | 4 (40.0) | 15 (30.0) | |
| Vertical | 1 (10.0) | 7 (14.0) | |
| Distance Score rg 38—IAN | | | 0,206 |
| None | 1 (10.0) | 2 (4.0) | |
| Low (< 1 mm) | 8 (80.0) | 20 (40.0) | |
| Medium (1—2 mm) | 1 (10.0) | 15 (30.0) | |
| Far (> 2 mm) | 0 (0) | 13 (26.0) | |
| Depth—tooth 38 | | | 0,126 |
| A | 1 (10.0) | 13 (26.0) | |
| B | 4 (40.0) | 22 (44.0) | |
| C | 5 (50.0) | 15 (30.0) | |
| Class P & G rg 38 | | | 0,340 |
| I | 2 (20.0) | 18 (36.0) | |
| II | 5 (50.0) | 29 (58.0) | |
| III | 3 (30.0) | 3 (6.0) | |
| Bone Coverage—tooth 38 | | | 0,100 |
| None | 0 (0) | 3 (6.0) | |
| Superficial (< 1 mm) | 4 (40.0) | 22 (44.0) | |
| Medium (1—3 mm) | 4 (40.0) | 25 (50.0) | |
| Deep (> 3 mm) | 2 (20.0) | 0 (0) | |
| Age > 26 | 5 (50.0) | 29 (58.0) | 0,634 |
| Risk Score—tooth 38 | | | 0,380 |
| Low | 0 (0) | 7 (14.0) | |
| Medium | 6 (60.0) | 26 (52.0) | |
| High | 4 (40.0) | 17 (34.0) | |
| Mean min. Distance to IAN ± SD (mm)—tooth 38 | 0.33 ± 0.50 | 0.94 ± 0.91 | **0,045** |
| Mean Bone Coverage ± SD (mm)—tooth 38 | 2.43 ± 2.43 | 1.08 ± 0.90 | **0,004** |
| Mean Risk Scale ± SD—tooth 38 | 6.22 ± 1.20 | 6.14 ± 1.39 | 0,432 |
| Gingivaplastic | 9 (90.0) | 36 (72.0) | **0,024** |
| Operation Time in minutes | 74.30 ± 35.47 | 48.19 ± 21.95 | **0,002** |
| Time per Tooth in minutes | 23.93 ± 4.83 | 17.34 ± 5.97 | **0,001** |
| CMFS | 2 (20.0) | 40 (80.0) | **0,025** |

**Table 14** Analysis of risk factors for hypesthesia in the right inferior alveolar nerve (tooth 48)

| Variable | Hypesthesia ($n = 9$) | No Hypesthesia ($n = 54$) | *p*-Value |
|---|---|---|---|
| Preexisting Disease | 2 (22.2) | 7 (13.0) | 0,201 |
| Medication | 2 (22.2) | 3 (5.6) | **0,036** |
| Operation under general anesthesia | 2 (22.2) | 15 (27.8) | 0,940 |
| Indication for operation/complaint | | | |
| Pain | 9 (100.0) | 45 (83.3) | 0,076 |
| Infection | 3 (33.3) | 12 (22.2) | 0,234 |
| Orthodontics | 3 (33.3) | 25 (46.3) | 0,929 |
| Prosthetics | 0 (0) | 4 (7.4) | 0,465 |
| Before Deployment | 0 (0) | 5 (9.3) | 0,411 |
| Marginal to IAN—tooth 48 | 8 (88.9) | 46 (85.2) | 0,191 |
| Angulation Types 48 | | | 0,207 |
| Mesio-angulated | 2 (22.2) | 23 (42.6) | |
| Disto-angulated | 3 (33.3) | 12 (22.2) | |
| Horizontal | 2 (22.2) | 15 (27.8) | |
| Vertical | 2 (22.2) | 4 (7.4) | |
| Distance Score rg 48—IAN | | | 0,246 |
| None | 0 (0) | 1 (1.9) | |
| Low (< 1 mm) | 8 (88.9) | 22 (40.7) | |
| Medium (1—2 mm) | 0 (0) | 22 (40.7) | |
| Far (> 2 mm) | 1 (11.1) | 9 (16.7) | |
| Depth—tooth 48 | | | 0,814 |
| A | 2 (22.2) | 9 (16.7) | |
| B | 5 (55.6) | 29 (53.7) | |
| C | 2 (22.2) | 16 (29.6) | |
| Class P & G rg 48 | | | 0,908 |
| I | 3 (33.3) | 20 (37.0) | |
| II | 4 (44.4) | 29 (53.7) | |
| III | 2 (22.2) | 5 (9.3)) | |
| Bone Coverage—tooth 48 | | | 0,890 |
| None | 1 (11.1) | 4 (7.4) | |
| Superficial (< 1 mm) | 3 (33.3) | 23 (42.6) | |
| Medium (1—3 mm) | 5 (55.6) | 26 (48.1) | |
| Deep (> 3 mm) | 0 (0) | 1 (1.9) | |
| Age > 26 | 2 (22.2) | 33 (61.1) | 0,167 |
| Risk Score—tooth 48 | | | 0,405 |
| Low | 0 (0) | 7 (13.0) | |
| Medium | 4 (44.4) | 32 (59.3) | |
| High | 5 (55.6) | 15 (27.7) | |
| Mean min. Distance to IAN ± SD (mm)—tooth 48 | 0.46 ± 0.64 | 0.92 ± 0.84 | 0,111 |
| Mean Bone Coverage ± SD (mm)—tooth 48 | 1.14 ± 0.91 | 2.74 ± 11.25 | 0,690 |
| Mean Risk Scale ± SD—tooth 48 | 6.75 ± 1.17 | 5.96 ± 1.26 | 0,102 |
| Gingivaplastic | 7 (77.8) | 39 (72.2) | 0,191 |
| Operation Time in minutes | 68.33 ± 23.98 | 48.99 ± 24.83 | **0,030** |
| Time per Tooth in minutes | 21.11 ± 4.78 | 17.72 ± 6.29 | 0,123 |
| CMFS | 2 (22.2) | 41 (75.9) | **0,044** |

any significant differences in postoperative complications during third molar extraction between oral/maxillofacial surgeons and general dentistry residents [21]. However, to date, there are hardly any studies comparing oral vs. maxillofacial surgeons regarding impacted third molar extraction and their perioperative complications.

The complication rates regarding transient hypesthesia were 8.1% for the left IAN and 7.3% for the right IAN. In comparison with international studies, these rates vary within described complication rates between 0.35—8.4% (in younger patients up to 9.8%) [11, 12]. The minimum distance to IAN, the bone coverage score, the total operation time and the operation by an oral surgeon (DMD) were identified as significant risk factors for hypesthesia of the left Ian. Patients who were operated on by a maxillofacial surgeon (MD, DMD) again showed lower complication rates. The total operation time was also shown to be a significant risk factor for the occurrence of hypoesthesia of the right IAN.

Sarikov et al. identified patient´s age (> 24 years old), horizontal impactions and extraction by trainee surgeons as a risk factor increasing the risk of IAN damage [11]. However, a differentiation between oral (DMD) and maxillofacial surgeon (MD, DMD) was not made. The prospective study by Bataineh et al. showed a significant correlation of surgeon´s experience and the occurrence of transient IAN hypesthesia [12]. However, no differentiation of the type of surgeon was performed. Furthermore, the study by Bataineh et al. showed that the incidence of IAN most frequently occurred in a younger age group (< 20-year-old), in direct comparison with the study by Sarikov et al. (> 24 years old) [11, 12]. Therefore, a conclusive assessment of age as a risk factor for hypesthesia cannot be made.

The present work is one of the first to present the current status of the complication patterns of impacted third molar surgery in a (Northern-)German population. These results are limited by the monocentricity of the study, the retrospective study design and the medium-sized study collective. In addition, the training paths of becoming a maxillofacial surgeon are not uniform in Europe and must be considered when interpreting the current findings in an international context. While in some countries (i.e. Germany) the dual license (Medical Doctor (MD), Dentist (DMD/DDS) = 12 years of medical/dentistry school + minimum 5 years of residency) is required for the board qualification as a maxillofacial surgeon, in other European countries (i.e. France, Spain) the medical license (MD) with subsequent residency training (minimum of 5 years) is sufficient to become a board qualified maxillofacial surgeon. Consequently, there are differences in time (up to 5 years) and in the scope of training to become a maxillofacial surgeon in different European countries, which must be considered as a limiting factor when interpreting the data. Consequently, there is a need for further large international multi-center studies to analyze these complications in more detail. Furthermore, this study is one of the first showing higher complication rates (OAC, IAN hypesthesia) in impacted third molar surgery regarding the type of surgeon (Oral surgeon vs. Maxillofacial surgeon). In addition to that, new risk factors (bone coverage, operation time, minimum distance measurements to IAN and maxillary sinus) regarding the most common complications (OAC, IAN hypesthesia) were identified and should be verified in future studies.

## Conclusion

The aim of this retrospective study was to determine the distribution of complications in deeply impacted third molar extraction, to identify specific risk factors (impaction patterns, angulations, bone coverage, distance scores) influencing the most common perioperative complications in deeply impacted third molar surgery (OAC, IAN hypesthesia). The general complication rates of OAC and IAN hypesthesia showed comparable rates to international studies. The distance to maxillary sinus, the depth score according to Pell and Gregory, the bone coverage score, the operation time, the tooth's angulation and the type of surgeon (oral surgeon, DMD) were identified as significant risk factors for the occurrence of OAC. The minimum distance to IAN, the bone coverage score, the total operation time and the operation by an oral surgeon (DMD) were identified as significant risk factors for hypesthesia of the IAN. The results of this study can serve as a baseline for further investigations of complications in impacted third molar surgery.

**Author contributions** KOH, FB and FD treated the patients and revised the article. FD and FB researched the scientific literature, provided statistical findings/analysis and wrote the article. All Authors gave final approval for publication.

**Funding** The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

**Data availability** No datasets were generated or analysed during the current study.

## Declarations

**Ethics approval and consent to participate** This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was waived by the clinical Ethics Committee of the Army Hospital/ German army research committee (IRB). All the procedures/diagnostics being performed were part of the routine care. Informed consent was waived by the clinical ethical board due to the retrospective nature of the study.

**Consent for publication** All authors gave final approval for publication.

**Consent to participate** None.

**Consent to publish** The authors affirm that human research participants provided informed consent for publication of the images/figures.

**Competing interests** The authors declare no competing interests.

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