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Current orthognathic surgery practices: A comprehensive survey from planning to discharge in Oral and Maxillofacial Surgery

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ABSTRACT

Detailed information on orthognathic surgery (OGS) practices in Germany, including treatment modalities, surgical concepts, and perioperative care standards, is limited. This study analyzed current practices along the patient pathway, from preoperative planning to discharge, through a nationwide survey of the German Association of Oral and Maxillofacial Surgery using dynamic online questionnaires (up to 56 questions). Responses from 169 surgeons (response-rate 9.2%) revealed substantial variability in training, perioperative care, and digital workflow adoption. While 44.4% used a hybrid of digital and conventional planning methods, broader digital integration was limited by high costs and logistical challenges. Perioperative care varied, particularly in support concepts, blood management, and antibiotic prophylaxis duration, with shorter regimens (≤24h) more common at university-hospitals and private practices. However, 98% agreed on the use of prophylaxis. Surgical approaches were more standardized, with most respondents favoring pre-surgical orthodontics, third molar extraction before OGS, and the maxilla-first approach. Postoperatively, 76% transferred patients to standard care, with 3–5 days discharge times. Significant correlations were observed between surgeon experience, case volume, and improved outcomes, including reduced operative time and faster discharge. These findings underscore the need for standardized OGS protocols to enhance patient safety, optimize recovery, and ensure consistent practices across healthcare settings.

1. Introduction

Orthognathic surgery (OGS) is highly favored by many maxillofacial surgeons due to its demand for advanced surgical skills and a profound understanding of the stomatognathic system (Mathew et al., 2020). Significant advancements have been achieved in recent years, primarily through digitalizing treatment processes. Innovations include new acquisition methods such as cone beam computed tomography (CBCT), computed tomography (CT), and intraoral scanners, along with enhanced processing software for Computer-Aided Design/-Manufacturing (CAD/CAM) (Kim et al., 2023). These technologies, combined with 3D printing techniques like direct metal laser sintering (DMLS), now enable the fabrication of highly accurate, patient-specific cutting guides and implants that are precisely tailored to the individual's anatomy (Swennen et al., 2009). Despite these advancements, challenges remain in the widespread adoption of these technologies, including high costs, the requirement for specialized training, and the integration of software and hardware solutions into routine clinical workflows (Swennen et al., 2009; Lee and Kim, 2023).

Furthermore, changes in patient healthcare have resulted from improved anesthesia and care protocols, changing patient expectations influenced by easy access to information and social media, and increasing economic pressures on healthcare (Mathew et al., 2020; Bär et al., 2024). Since 2010, the Enhanced Recovery after Surgery (ERAS)

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Society has significantly optimized perioperative care (Ljungqvist et al., 2017). By implementing evidence-based, multimodal, and multidisciplinary perioperative care programs, traditional patient care in surgical departments has been fundamentally transformed and standardized based on published evidence (Kehlet and Dahl, 2003; Ljungqvist, 2014; Ljungqvist et al., 2017). Implementing ERAS guidelines in various surgical specialties has demonstrably shortened recovery times, reduced postoperative complication rates, and proven cost-effective (Muller et al., 2009; Gustafsson et al., 2011; Group, 2015). Despite ample evidence supporting their benefits, these guidelines must be more present in Oral and Maxillofacial Surgery (OMFS) and OGS (Bär et al., 2024). Furthermore, these innovative care approaches receive less focus than technological advancements in the context of overall progress in OGS.

Detailed information on the standards of clinical OGS practice within German OMFS is scarce. Clinical guidelines covering the breadth of these innovations are lacking, revealing a gap in our understanding of how these advancements are implemented in different healthcare settings.

This study aims to provide a comprehensive overview of current treatment modalities, surgical concepts, and especially perioperative care standards in German OGS. It focuses on implementing and integrating these innovations throughout the treatment pathway, from preoperative planning to patient discharge. It is hypothesized that there is considerable variability in treatment patterns between university hospitals, non-university hospitals, and private practices. Additionally, the influence of factors such as surgical volume, surgeon experience, and the type of medical institution will be analyzed.

This research is intended to deepen our understanding of OGS practices in Germany and offer a basis for discussion that could lead to further standardization of procedures to enhance patient safety, satisfaction, and effectiveness of these elective surgical procedures.

2. Methods

A nationwide survey conducted by the Young Forum of the German Society of Oral and Maxillofacial Surgery (Junges Forum der Deutschen Gesellschaft für Mund-, Kiefer-und Gesichtschirurgie; DGMKG) employed dynamic online questionnaires containing 56 questions, analogous to those used in previous studies (Pabst et al., 2019, 2021; Zeller et al., 2023). The complete survey questions and their results are in the supplementary material. The survey created using the Momentive® system (formerly SurveyMonkey®) included multiple-choice, rating, and open-ended questions. The questionnaire was written in German and covered various topics, from general data collection to complex details on the pre-, intra- and postoperative management of OGS. It was designed to be completed within 8–10 min to avoid a high dropout rate despite participants' willingness to engage in the survey. Rating questions used rating scales and a ruler-controlled visual analog scale. Occasionally, optional follow-up questions were included based on respondents' answers to previous questions. These optional follow-up questions depended on the preceding answers.

As the survey focused on expert opinions and their inherent nature, ethics approval was waived according to the Joint Ethics Committee of the Universities of Bavaria (GEHBa, Gemeinsame Ethikkomission der Hochschulen Bayerns). This study was conducted in accordance with the principles of the Declaration of Helsinki. It was approved and supported by the Steering Committee of the Study Administration of the DGMKG. The initial validation of the questionnaire was performed internally through careful test runs and extensive consideration. External validation was conducted through test runs involving three highly experienced, full board-certified OMFS and three residents, all of whom had performed at least 50 orthognathic procedures and came from departments known for a high volume of orthognathic procedures (50–100 procedures per year). Both the internal and external evaluations were conducted by maxillofacial surgeons who did not participate in the subsequent study. Any discrepancies or issues identified during the validation process were carefully addressed through collaborative discourse and iterative refinement of the survey instrument. The general survey criteria of understandability, accuracy, and topic specificity were assessed for each question. Key questions were identified, and potential concerns were addressed through group discussions. After validation, the questionnaire was distributed to OMFS registered in the registry of the DGMKG, including university and non-university hospitals and private practices. Dissemination was achieved by distributing a web link and a comprehensive explanatory email outlining the study's aims and encouraging active participation. To increase the response rates, proactive reminders were sent in cases of non-response at 1 and 3-month intervals. Participation in the study was entirely voluntary and anonymous. Contact information provided was temporarily stored solely to facilitate reminder procedures during the collection phase. Initial data storage was performed using the Momentive® platform and was subsequently exported to Excel® (Microsoft Office, Microsoft Corporation, Redmond, USA), with safeguards in place to prevent linking contact information to survey responses. Data for correlation analysis were subsequently imported into GraphPad Prism (Version 9, GraphPad Software Inc., Boston, USA). The variables "years of experience", "performed OGS cases per year", "performed OGS cases in the clinic or practice per year", "average surgery time", "blood loss", "postoperative care station", and "discharge time" were treated as ordinal variables since they were presented in ascending rank intervals in the questionnaire. Figures were created using GraphPad Prism (Version 9, GraphPad Software Inc., Boston, USA). Spearman's rank correlation coefficient was employed to assess the relationship between two categorical variables. Statistical significance was defined as p-values $\leq$0.05.

3. Results

3.1. General data

The surveys were sent to all members of the DGMKG registered on the mailing list (n = 1829). A total of 169 surgeons from Germany participated in the study, resulting in a response rate of 9.2%. Of these, 70 participants (41.42%) were affiliated with university hospitals, 46 (27.22%) with non-university hospitals, 28 (16.57%) with hospitals that have inpatient departments, 11 (6.51%) with outpatient clinics providing 24-h on-site monitoring, and 14 (8.28%) with outpatient clinics lacking 24-h on-site monitoring. Regarding experience in OGS, 45 respondents (26.63%) had 1–5 years of experience, 24 (14.20%) had 6–10 years, 36 (21.30%) had 11–20 years, 38 (22.49%) had 21–30 years, and 26 (15.38%) had over 30 years of experience. In terms of annual orthognathic procedures performed individually, 36 respondents (21.43%) reported performing 5 or fewer procedures per year, 16 (9.52%) performed 6–10 procedures, 35 (20.83%) performed 11–20 procedures, 32 (19.05%) performed 21–40 procedures, 28 (16.67%) performed 41–60 procedures, and only 7 (4.17%) conducted more than 100 procedures annually. More than a third of the respondents (57; 34.34%) indicated that 51–100 orthognathic procedures are performed annually at their clinic or practice. Additionally, 22 participants (13.25%) reported fewer than or equal to 20 procedures, and 6 participants stated that more than 250 orthognathic surgeries are performed each year at their facility. Moreover, 53 respondents (31.93%) reported that 21–50 procedures are conducted at their clinic annually, 15 (9.04%) indicated 101–150 procedures, 8 (4.82%) reported 151–200 procedures, and only 5 (3.01%) indicated 201–250 procedures per year in their entire clinic or practice. The average proportion of revision procedures was found to be 5%, although this varied significantly, ranging from a minimum of 0% to a maximum of 65%.

3.2. Level of training

When inquired about the training level at which OGS is performed, 60 out of 157 respondents (38.22%) indicated that it is performed during residency. Another 59 participants (37.58%) stated that it starts from the specialist's period, while 36 respondents (22.93%) indicated that it begins only at the senior physician's status. Only 2 respondents mentioned that OGS is also performed by specialist dentists in oral surgery. Additionally, many free-text responses highlighted that these procedures are exclusively performed by certain surgeons within the clinic or practice. Training procedures are conducted in different ways: 34 out of 64 respondents (53.13%) reported that training is done through individual partial steps (such as surgical access, osteotomy, osteosynthesis, and wound closure), whereas 30 out of 64 participants (46.88%) indicated that training is conducted as a complete procedure under supervision.

3.3. Perioperative supportive measures

Regarding supportive measures for surgical preparation, such as patient education, physiotherapy, logopedics, nutritional advice, and psychological support as part of a standardized preoperative concept, 79 out of 169 respondents (46.75%) reported the absence of such a standardized concept. Conversely, 90 respondents (53.25%) confirmed the existence of a standardized concept in their clinic or practice. Among participants from private practices, 68% (17 out of 25) reported having a standardized preoperative concept for orthognathic surgery (OGS) patients, while in non-university hospitals, only 52.70% (39 out of 74) reported having such a concept, and in university hospitals, the figure was even lower at 48.57% (34 out of 70). Approximately 35% of all respondents indicated that patient training and physiotherapy are conducted preoperatively, and just over a quarter stated that logopedics is employed. Nutritional advice is included in the preoperative treatment plan for circa 21% of all 169 respondents, and psychological support is provided as a preoperative standard in approximately 10% of cases (Table 1). Postoperatively, most respondents (47 out of 84; 55.95%) reported that supportive measures continue for up to 3 months, while 27 out of 84 (32.14%) extend these measures up to 6 months, and only 2 out of 84 (2.38%) maintain them beyond this period. In most cases (53 out of 85; 62.35%), the responsibility for these measures remains with the respective practice or hospital outpatient department. Additionally, 45 out of 85 respondents (52.94%) refer patients to the outpatient sector for postoperative support. The least common approach, with 12.29% of cases, involves providing these measures as inpatient care. Notably, eight out of 84 respondents (9.52%) indicated that no supportive measures were carried out postoperatively.

3.4. Planning

Regarding planning techniques, most respondents (71 out of 160; 44.38%) reported using both modern CAD/CAM technology (including models, cutting and drilling guides, and patient-specific implants) and conventional methods based on plaster models. Among the clinics and practices that employ both methods, the average utilization of CAD/CAM technology is 59%. CAD/CAM production is carried out in-house in 65.63% (21 out of 32 answers). Over a third of those surveyed (57 out of 160; 35.63%) rely solely on conventional technology, while one-fifth (32 out of 160; 20%) plan their cases purely virtually. Most respondents (27 out of 33; 81.82%) who use CAD/CAM technology apply it for both maxillary and mandibular osteotomies (including genioplasty). A smaller portion (5 out of 33; 15.15%) use CAD/CAM technology only for maxillary osteotomies, and only one participant exclusively for mandibular osteotomy. The primary reasons cited for not utilizing CAD/CAM techniques include the high costs (60.71%), the time required (42.86%), and the organizational effort involved (58.93%).

3.5. Surgical procedure

Most clinics and practices (105 out of 152; 69.08%) remove impacted wisdom teeth more than 6 months prior to OGS, with 13 respondents (8.55%) opting for removal more than 9 months before the procedure. A small proportion of respondents (3.95%) defer the removal of impacted wisdom teeth until after OGS, performing the extraction alongside the removal of osteosynthesis material. Fifteen respondents (9.87%) combined the removal of wisdom teeth with OGS in the same operation. Similar trends are observed for partially impacted wisdom teeth. Most respondents (108 out of 151; 71.52%) indicated that they removed partially impacted wisdom teeth more than 6 months before OGS. An even smaller proportion (2.65%) waits until the removal of osteosynthesis material to extract these teeth.

More than half of the participants (86 out of 159; 54.09%) stated that they use the surgery-first concept, but predominantly (71 out of 86; 82.56%) in less than 10% of cases. The maxilla is typically osteotomized first in the intraoperative procedure for a bimaxillary osteotomy. Specifically, 99 out of 150 respondents (66%) reported always using the maxilla-first approach, while 38 respondents (25.33%) stated that they chose the maxilla-first approach in more than 50% but less than 100% of cases. Conversely, the mandible is started much less frequently. Only 4 out of 150 respondents (2.67%) always use the mandible-first approach, 5 participants (3.33%) use the mandible-first approach in more than 50% but less than 100% of cases, and 4 respondents (2.67%) alternate equally between the maxilla-first and mandible-first approaches.

The average surgery time (cutting to suturing) for a bimaxillary osteotomy is reported by 41.45% (63 out of 152) of the participants as 3–4 h. Additionally, 54 participants (35.53%) estimate their average surgery time as 2–3 h. In contrast, 12 respondents (7.89%) indicate that the procedure takes less than 2 h on average, and one participant (0.66%) reports an average duration of more than 6 h. Twenty-two respondents (14.47%) estimate the surgery time to be 4–6 h. They are considering intraoperative blood pressure management. Of the survey participants, 62 out of 148 (41.89%) favor controlled hypotension as the target blood pressure during OGS. Meanwhile, 29 respondents (19.59%) prefer maintaining normal blood pressure, and 57 participants (38.51%) do not adhere to a specific target blood pressure. From a purely descriptive perspective, the percentage values show minimal differences between the individual facilities and are consistent with the overall response rate (Table 2).

Regarding average blood loss during a bimaxillary osteotomy, over half of the respondents (51.97%; 79 out of 152) estimate the loss to be between 200 and 400 ml. Thirty participants (19.74%) consider a blood loss of less than 200 ml to be plausible. Conversely, 36 respondents (23.68%) estimate the blood loss to be between 400 and 600 ml, while 5 respondents (3.29%) estimate it to be between 600 and 800 ml. No participants expect blood loss to exceed 800 ml.

The question concerning the type of osteosynthesis most frequently received the response "Prefabricated, load-sharing osteosynthesis plate," chosen by 64.90% (98 out of 151) of the respondents. Additionally, 64 respondents (42.38%) reported using indication-specific osteosynthesis

Table 1
Standardized preoperative concepts and supportive measures in orthognathic surgery across different institution types.

	Standardized preoperative concept	Patient training	Physiotherapy	Logopedics	Nutritional advice	Psychological support
University hospitals	34/70 (48.57%)	23/70 (32.86%)	21/70 (30.00%)	18/70 (25.71%)	11/70 (15,71%)	8/70 (11.43%)
Non-university hospitals	39/74 (52.70%)	24/74 (32.43%)	26/74 (35.14%)	16/74 (21.62%)	20/74 (27.03%)	8/74 (10.81%)
Private practice	17/25 (68.00%)	13/25 (52.00%)	14/25 (56.00%)	10/25 (40.00%)	5/25 (20.00%)	1/25 (4.00%)
	90/169 (53.25%)	60/169 (35.50%)	61/169 (36.09%)	44/169 (26.04%)	36/169 (21.30%)	17/169 (10.06%)

Table 2
Blood pressure management strategies in orthognathic surgery by institution type.

	Controlled hypotension	Normal blood pressure	No target blood pressure
University hospitals	23/60 (38.33%)	11/60 (18.33%)	26/60 (43.33%)
Non-university hospitals	31/69 (44.93%)	15/69 (21.73%)	23/69 (33.33%)
Private practice	8/19 (42.11%)	3/19 (15.79%)	8/19 (42.11%)
	62/148 (41.89%)	29/148 (19.59%)	57/148 (38.51%)

Table 3
Use of tranexamic acid (TXA) in orthognathic surgery by institution type.

	Tranexamic acid	1g i.v.	1g p.o.	Locally
University hospitals	21/61 (34.43%)	17/61 (27.87%)	0/61 (0.00%)	5/61 (8.20%)
Non-university hospitals	30/71 (42.25%)	24/71 (33.80%)	3/71 (4.23%)	5/71 (7.04%)
Private practice	10/20 (50.00%)	5/20 (25.00%)	0/20 (0.00%)	4/20 (20.00%)
	61/152 (40.13%)	46/152 (30.26%)	3/152 (2.00%)	14/152 (9.21%)

plates (e.g., special orthognathic surgery plates). Screw osteosyntheses and patient-specific implants were each utilized by 17.22% (26 out of 151) of the respondents.

Most participants (48.34%; 73 of 151) perform intermaxillary fixation (IMF) following OGS, while 21.85% use IMF only occasionally, and almost a third (29.80%; 46 of 151) do not apply IMF after osteosynthesis. Typically, IMF is secured elastically (95.10%; 97 of 102) using brackets with hooks (85.44%), followed by Kobayashi hooks (67.96%) and IMF screws (47.57%). Additionally, 20 of 102 participants (19.61%) reported using rigid fixation, and 10 of 102 (9.8%) employed a combination of rigid and elastic fixation.

Postoperative occlusion is always secured with a final splint in most clinics and practices (55.03%; 82 of 149). Some clinics (28.86%; 43 of 149) use a final splint occasionally, while 16.11% (24 of 149) do not use a final splint to secure postoperative occlusion. These splints are conventionally manufactured by 47.2% (59 of 125) of respondents, while 36% use CAD/CAM splints. Both types are available in 16.8% (21 of 125) of clinics, with the choice being made intraoperatively. If a splint is inserted postoperatively, 18.25% (23 of 126) of participants remove it in less than 5 days. For 42.86% (54 of 126), the splint is removed after 6–14 days, and 29.37% (37 of 126) of clinics and practices remove the splint within 2–4 weeks. Only 12 participants reported leaving the splint in place for longer than 4 weeks.

3.6. *Preoperative and postoperative imaging techniques*

For preoperative imaging, the majority of clinics and practices utilize panoramic tomography (79.61%; 121 out of 152), cephalometric lateral views (71.71%; 109 out of 152), and CBCT (80.26%; 122 out of 152). In contrast, computed tomography (17.11%; 26 out of 152) is markedly less common, and hand X-rays (5.92%; 9 out of 152) are rarely employed. Regarding postoperative imaging, most respondents (84.31%; 129 out of 153) reported that at least one panoramic tomography was performed. Additionally, nearly half of the patients undergo cephalometric lateral views (51.63%; 79 out of 153) and CBCT (53.59%; 82 out of 153). Less frequently, mandibular X-rays according to Clementschitsch (16.34%; 25 out of 153) and CT (5.23%; 8 out of 153) are conducted.

3.7. *Perioperative management*

Nearly all clinics and practices utilize local methods in addition to general anesthesia for analgesia. Among the participants, 147 out of 152 (96.71%) reported using regional infiltration, 25 (16.45%) employed nerve block anesthesia, and only 3 (1.97%) forego local anesthesia entirely. To reduce bleeding, intravenous (IV) administration of tranexamic acid (TXA) is a common approach. Nearly a third of respondents (30.26%; 46 out of 152) administer 1 g IV as a bolus intraoperatively, 3 respondents (2.00%), exclusively from non-university hospitals, use oral administration of 1 g (up to three times daily for 1–3 days preoperatively), and 14 (9.21%) apply the drug locally. In contrast, almost 60% (91 out of 152) do not use TXA (Table 3).

Thrombosis prophylaxis is conducted by 111 out of 151 respondents (73.51%). Most (89.72%; 96 out of 107) use low molecular weight heparins (LMWH), while 31 participants employ non-medicinal measures such as shortening preoperative immobilization, early mobilization, physiotherapy, and compression stockings. Additionally, 11 participants (10.28%) administered unfractionated heparin. Most respondents (73.61%; 53 out of 72) initiate anticoagulation perioperatively, a quarter (25%; 18 out of 72) begin up to 24 h before surgery, and 1 participant (1.39%) starts more than 3 days preoperatively. Anticoagulation is typically continued until discharge (65.38%; 68 out of 104), with 31 participants (29.81%) extending prophylaxis for 1–3 days perioperatively and 5 (4.81%) up to 24 h.

Nearly all respondents (146 out of 149; 97.99%) reported administering perioperative antibiotic prophylaxis. Twenty-three out of 149 respondents (15.44%) provide a preoperative single shot, while 69 out of 149 (46.31%) administer antibiotics for a maximum of 24 h, and 54 out of 149 (36.24%) for more than 24 h. Most participants from university hospitals and private practices administer antibiotics for a maximum of 24 h. In contrast, non-university hospitals typically provide antibiotics for more than 24 h (Table 6). The most commonly used antibiotics are ampicillin or amoxicillin with a β-lactamase inhibitor (65.10%; 97 out of 149). Among these respondents, 41 out of 58 from university hospitals (70.69%), 48 out of 71 from non-university hospitals (67.61%), and only 8 out of 20 from private practices (40.00%) administer this antibiotic drug. Forty-five participants (30.20%) prescribed clindamycin for those with penicillin intolerance. Twenty participants (13.42%) administered ampicillin or amoxicillin without a β-lactamase inhibitor, and 30 (20.13%) opted for cefuroxime. Eleven participants (7.38%) chose clindamycin regardless of penicillin tolerance, with 20% (4 out of 20) among respondents from private practices, 7% (5 out of 71) in non-university hospitals, and only about 3.5% (2 out of 58) in university hospitals (Table 7).

Seventy percent of respondents (104 out of 148; 70.27%) report administering glucocorticoids for swelling prophylaxis, and approximately the same proportion (103 out of 148; 69.59%) employ local measures such as cold compresses (65 out of 104; 62.50%), accurate thermotherapy (e.g., Hilotherm® or similar) (63 out of 104; 60.58%), bandages and/or facial pressure bandages (20 out of 104; 19.23%), and post-operative wound drainage (e.g., suction drainage) (41 out of 104; 39.42%). Glucocorticoids are most commonly administered intraoperatively as a bolus (95 out of 138; 68.84%), and some participants also report post-operative administration for 24 h (13.77%), 48 h (8.70%) or up to 72 h (6.52%). No clinics or practices reported preoperative administration or administration beyond 72 h.

More than half of the participants (81 out of 146; 55.47%) do not insert a urinary catheter. In contrast, 20 participants (13.70%) always insert a urinary catheter, while 45 participants (31.03%) decide based on the duration of the surgery. The removal of the catheter occurs immediately after the end of surgery in 47.69% (31 out of 65), after the first mobilization in 35.38% (23 out of 65), and within the first postoperative 24 h in 12.31% (8 out of 65). Only 3.08% (2 out of 65) leave the catheter in place for more than 24 h Only 2 participants from private practices (11.11%) reported inserting a urinary catheter, compared to 36.62% in non-university hospitals and even 64.91% in university hospitals (Table 4).

Regarding nasogastric (feeding) tubes, 69.66% (101 out of 145) of respondents do not use them. However, 30.34% of participants indicate that nasogastric tubes are part of their perioperative standard, with 47.50% (19 out of 40) leaving the tube in place for more than 24 h. Nine participants (22.50%) removed the tube immediately after surgery, 12.5% (5 out of 40) after the first postoperative visit within the first 3–6 h, and 17.50% (7 out of 40) within the first 24 h. Only 2 participants from private practices (11.11%) reported inserting nasogastric (feeding) tubes, which are immediately removed, compared to 28.57% in non-university hospitals and 38.60% in university hospitals, where the tubes are left in place for more than 24 h in approximately 50% of cases (Table 5).

Most respondents (107 out of 141; 75.89%) report that a healthy patient (ASA 1) is transferred from the recovery room to standard care after bimaxillary osteotomy surgery, with initial mobilization typically occurring directly postoperatively (75 out of 144; 52.08%) or within the first 24 h (55 out of 144; 38.19%). A smaller proportion (25 out of 141; 17.73%) transfer the patient to intermediate care, and 7 respondents (4.96%) monitor the patient in high care. Conversely, 10 respondents (7.09%) perform the surgery as an outpatient procedure, allowing the patient to be discharged home.

The reported average discharge time after bimaxillary osteotomy varies widely among respondents, typically within five days. Four participants (2.80%) discharged patients on the day of surgery, 7 participants (4.90%) on the first postoperative day, 24 participants (16.78%) on the second postoperative day, 40 participants (27.97%) on the third postoperative day, another 24 participants (16.78%) on the fourth postoperative day, and 33 participants (23.08%) on the fifth postoperative day. Only 11 respondents (7.69%) keep patients for longer than five days post-surgery.

The postoperative complications reported by most clinics and practices over the past 10 years include "fracture of the osteosynthesis material/screw loosening and necessary re-osteosynthesis" (62.96%, 85 out of 135), "permanent anesthesia" (60.74%, 82 out of 135), and "bleeding requiring intervention" (52.59%, 71 out of 135).

3.8. Correlation analysis

Spearman's rank correlation coefficient revealed a significant moderate negative correlation between "years of experience" and "average surgery time" ($r = -0.3289$; $p < 0.001$), as well as a significant negative correlation between "years of experience" and "discharge time" ($r = -0.3382$; $p < 0.001$). In contrast, no correlation was observed between "years of experience" and "blood loss" ($p = 0.764$), nor between "years of experience" and "postoperative care station" ($p = 0.323$) (Fig. 1).

A significant moderate negative correlation was found between "performed OGS cases per year" and "average surgery time" ($r = -0.4206$; $p < 0.001$), and a significant negative correlation was also noted between "performed OGS cases per year" and "discharge time" ($r = -0.2134$; $p = 0.011$). On the other hand, no correlation was detected between "performed OGS cases per year" and "blood loss" ($p = 0.276$) or between "performed OGS cases per year" and "postoperative care station" ($p = 0.288$) (Fig. 2). Regarding "performed OGS cases in the clinic or practice per year," a significant moderate negative correlation was identified with "average surgery time" ($r = -0.1857$; $p = 0.022$). However, no significant relationships were found between "performed OGS cases in the clinic or practice per year" and "discharge time" ($p = 0.713$), "blood loss" ($p = 0.242$), or "postoperative care station" ($p = 0.621$) (Fig. 3).

4. Discussion

In recent years, significant advancements in various aspects of OGS have been achieved. This survey was conducted to provide a comprehensive overview of current treatment modalities, surgical concepts, and especially perioperative care standards in German OGS. It focuses on implementing and integrating these innovations throughout the treatment pathway, from preoperative planning to patient discharge. While there was a response rate of 9.2%, the data still offers valuable insights into training, experience level, and perioperative management. The response rate aligns with other survey-based studies (Pabst et al., 2021; Sayre et al., 2021; Bourne and Kinard, 2023; Ronde et al., 2023).

Most respondents practice in university hospitals (41%) or non-university hospitals (43%), with only 14.8% working in private practice. A large U.S. cross-sectional analysis examining the impact of surgical volume on patient outcomes defined high-volume hospitals as those exceeding the 90th percentile of annual orthognathic treatment volume, which Berlin et al. determined to be more than 31 cases per year (Berlin et al., 2016). Overall, 29% of respondents in the survey were high-volume surgeons, performing more than 40 surgeries annually. Interestingly, the highest proportion of experienced surgeons (>40 surgeries/year) was found in non-university hospitals (57.1%). This may be due to these institutions' typically smaller department sizes, leading to a higher concentration of cases per surgeon. In contrast, university hospitals, which often serve as teaching and training centers, had a higher proportion of less experienced surgeons (66.6%) and a relatively lower proportion of high-volume surgeons (24.5%) among the study participants. This discrepancy reflects the role of university hospitals in providing training opportunities, where a greater number of resident surgeons perform procedures under supervision.

There is also considerable variability in the nature and timing of OGS training. While most respondents indicated that training begins during residency or at the specialist level, 22.93% reported that it only starts at the senior physician level. Notably, this later start is more common in smaller non-university hospitals and private practices, where individual responses suggested that training is often limited or nonexistent. The reasons for this may be multifaceted and potentially influenced by these institutions' financial constraints (Dolan and White, 1996; Zins et al., 2005). However, it is essential to recognize that these findings reflect self-reported data and may only capture part of the spectrum of training practices across some institutions. Nonetheless, they underscore the potential value of a structured and standardized training program to ensure consistent qualifications among surgeons, irrespective of the training environment (Carter and Mohammad, 2009).

There is considerable heterogeneity in perioperative management

Table 4
Urinary catheter usage and removal timing in orthognathic surgery by institution type.

	Urinary catheter (always)	Urinary catheter (duration-dependent)	Immediate removal	Removal after the first mobilization	Removal ≤24 h	Removal >24 h
University hospitals	10/57 (17.54%)	27/57 (47.37%)	20/57 (35.09%)	13/57 (22.81%)	3/57 (5.26%)	1/57 (1.75%)
Non-university hospitals	10/71 (14.08%)	16/71 (22.54%)	11/71 (15.49%)	10/71 (14.08%)	4/71 (5.63%)	1/71 (1.41%)
Private practice	0/18 (0.00%)	2/18 (11.11%)	0/18 (0.00%)	0/18 (0.00%)	1/18 (5.56%)	0/18 (0.00%)
	20/146 (13.70%)	45/146 (30.82%)	31/146 (21.23%)	23/146 (15.75%)	8/146 (5.48%)	2/146 (1.37%)

Table 5
Nasogastric tube usage and removal timing in orthognathic surgery by institution type.

	Nasogastric tubes	Immediate removal	Removal within the first 3–6 h	Removal ≤24 h	Removal >24 h
University hospitals	22/57 (38.60%)	4/57 (7.02%)	2/57 (3.51%)	5/57 (8.78%)	10/57 (17.54%)
Non-university hospitals	20/70 (28.57%)	3/70 (4.29%)	3/70 (4.29%)	2/70 (2.86%)	12/70 (17.14%)
Private practice	2/18 (11.11%)	2/18 (11.11%)	0/18 (0.00%)	0/18 (0.00%)	0/18 (0.00%)
	44/145 (30.34%)	9/145 (6.21%)	5/145 (3.45%)	7/145 (4.83%)	22/145 (15.17%)

Table 6
Antibiotic prophylaxis in orthognathic surgery by institution type.

	Antibiotic prophylaxis	Preoperative single shot	≤24 h	>24 h
University hospitals	56/58 (96.55%)	9/58 (15.52%)	33/58 (56.90%)	14/58 (24.14%)
Non-university hospitals	71/71 (100.00%)	11/71 (15.49%)	25/71 (35.21%)	35/71 (49.30%)
Private practice	19/20 (95.00%)	3/20 (15.00%)	11/20 (55.00%)	5/20 (25.00%)
	146/149 (97.99%)	23/149 (15.44%)	69/149 (46.31%)	54/149 (36.24%)

practices. Nearly half of the respondents reported not having a standardized preoperative protocol that includes supportive measures such as patient education, physiotherapy, speech therapy, nutritional counseling, and psychological support. Given the potential benefits of structured pre- and postoperative care, the absence of standardized protocols represents a clear area for improvement in patient management (Otero et al., 2017; Mathew et al., 2020; Stratton et al., 2022; Bär et al., 2024). This lack of uniformity also extends to intraoperative measures like blood management. Although several meta-analyses have demonstrated the benefits of controlled hypotension and TXA in reducing blood loss and improving the surgical field, these practices remain underutilized, with 59.87% of respondents reporting not using TXA (Song et al., 2013; Olsen et al., 2016; Mei and Qiu, 2019; Siotou et al., 2019; Zhao et al., 2019; Sun et al., 2020). Interestingly, most respondents (71.7%) estimated an average blood loss of less than 400 ml, below the 436 ml reported in a systematic review by Piñeiro-Aguilar et al., who evaluated blood loss in OGS over three decades (Piñeiro-Aguilar et al., 2011). Interestingly, postoperative hemorrhage requiring intervention is one of the top three complications of the last ten years among the respondents, accounting for >50%.

In contrast, there is greater consensus regarding certain perioperative practices. More than 50% of respondents agreed on swelling and antibiotic prophylaxis and reported not using urinary catheters or nasogastric tubes—practices that align with recommendations in the literature (Baqain et al., 2004; Eshghpour et al., 2014; Brookes et al., 2015; Abukawa et al., 2017; Ferrara et al., 2022; Hattori et al., 2023). The near absence of urinary catheter use in private practices is particularly notable. This trend aligns with a focus on minimizing interventions to enhance patient comfort and reduce the risk of complications, such as urinary tract infections (Chenoweth, 2021). It may also reflect possible differences in patient demographics, as private practices may more care for patients classified as ASA 1. It is important to note that these findings rely on self-reported data, which may not accurately reflect broader trends or compliance across diverse clinical settings.

To minimize swelling, most respondents use postoperative cold applications (compresses or devices such as Hilotherm®) and intraoperative single doses of glucocorticoids. While several authors have demonstrated that perioperative systemic corticosteroids can effectively reduce facial edema and postoperative nausea and vomiting (PONV), without significant adverse effects, there is no consensus on an ideal steroid regimen supported by systematic reviews and meta-analyses is still lacking (Dan et al., 2010; de Lima et al., 2017; Jean et al., 2017; Bravo et al., 2022).

Semper-Hogg et al. showed in an RCT that 40 mg of IV dexamethasone administered preoperatively was more effective than control (Semper-Hogg et al., 2017). In contrast, Abukawa et al. observed a significantly reduced postoperative edema with 16 mg of IV dexamethasone (Abukawa et al., 2017). No benefit in neurosensory disturbances or shorter hospital stays has been observed thus far (de Lima et al., 2017; Jean et al., 2017; Semper-Hogg et al., 2017), and no ceiling effect has been demonstrated with prolonged dexamethasone administration (Weber and Griffin, 1994).

Regarding antibiotic prophylaxis, nearly all respondents (97.99%) reported administering perioperative antibiotics, aligning with recommendations in the literature. Multiple systematic reviews and meta-analyses support the use of perioperative antibiotics in OGS with good evidence (Tan et al., 2011; Brignardello-Petersen et al., 2015; Gil et al., 2021; Milic et al., 2021), though uncertainty remains regarding the optimal antibiotic choice and administration duration (Brignardello-Petersen et al., 2015; Naimi-Akbar et al., 2018; Gil et al., 2021). Among the respondents, 65.1% prescribing aminopenicillins combined with β-lactamase inhibitors. No consensus was found regarding the duration of use across institutions. The majority (46.31%) limited antibiotic administration to a maximum of 24 h, whereas 36.24% (54 out of 146) reported using antibiotics for more than 24 h, with an average duration of 5 days. This preference for shorter antibiotic courses was particularly notable in university hospitals and private practices, while non-university hospitals tended to extend the duration beyond 24 h. These findings mirror the heterogeneity observed in the literature. While systematic reviews by Gil et al. and Brignardello-Petersen et al. suggest that long-term antibiotic use may reduce the risk of surgical site infections in OGS (Brignardello-Petersen

Table 7
Choice of antibiotics in orthognathic surgery by institution type.

	Ampicillin or amoxicillin	Ampicillin or amoxicillin + β-lactamase inhibitor	Clindamycin	Clindamycin in penicillin intolerance	Cefuroxime	Others
University hospitals	8/58 (13.79%)	41/58 (70.69%)	2/58 (3.45%)	19/58 (32.76%)	9/58 (15.52%)	1/58 (1.72%)
Non-university hospitals	8/71 (11.27%)	48/71 (67.61%)	5/71 (7.04%)	22/71 (30.99%)	14/71 (19.72%)	2/71 (2.82%)
Private practice	4/20 (20.00%)	8/20 (40.00%)	4/20 (20.00%)	4/20 (20.00%)	7/20 (35.00%)	0/20 (0.00%)
	20/149 (13.42%)	97/149 (65.10%)	11/149 (7.38%)	45/149 (30.20%)	30/149 (20.13%)	3/149 (2.01%)

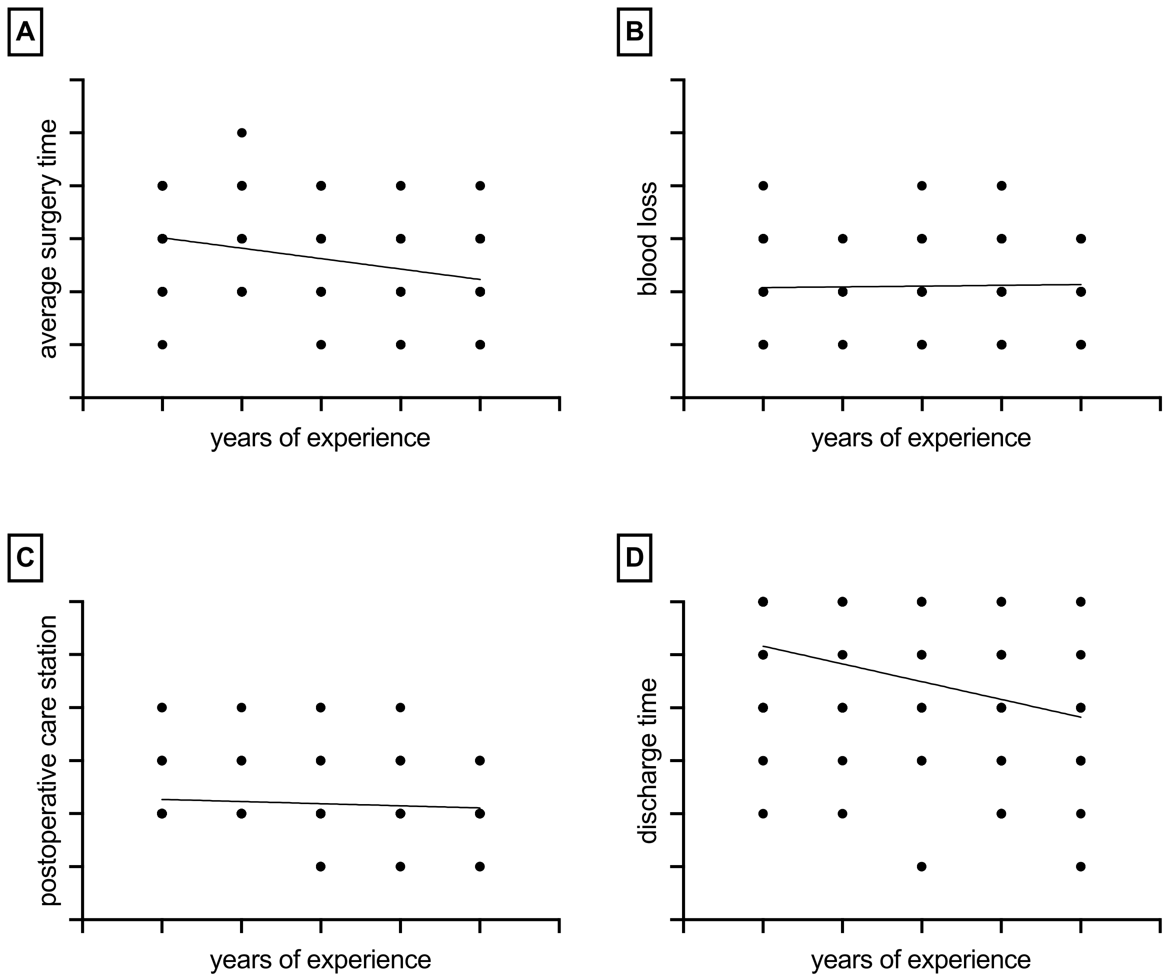

Fig. 1. Correlation Analysis of Surgical Experience (in Years) on Surgery Time, Discharge, Blood Loss, and Postoperative Care Duration
Scatter plots depict the relationships between surgical experience and key outcomes. A moderate negative correlation is noted between "years of experience" and "surgery time" (A, $r = -0.3289$; $p < 0.001$) and a significant negative correlation with "discharge time" (D, $r = -0.3382$; $p < 0.001$). No significant correlations were found with "blood loss" (B, $p = 0.764$) or "postoperative care duration" (C, $p = 0.323$). Axes reflect ordinal scaling based on response options (see Supplementary Materials).

et al., 2015; Gil et al., 2021), several randomized controlled trials and retrospective studies indicate that prolonged antibiotic therapy does not significantly lower the incidence of postoperative infections (Baqain et al., 2004; Jansisyanont et al., 2008; Eshghpour et al., 2014; Naros et al., 2023). Instead, the focus should be on aseptic surgical techniques, patient hygiene education, and avoiding smoking after surgery (Eshghpour et al., 2014; Naros et al., 2023). Further large-scale multicenter RCTs are needed to assess the optimal antibiotic regimen and duration to provide more definitive guidance for clinical practice.

Most respondents (75.9%) transfer their ASA I patients to standard care following bimaxillary osteotomy, where over half are mobilized immediately postoperatively, and nearly one-third are discharged on the third postoperative day. An additional 16.8% and 23.1% discharge patients on the fourth and fifth postoperative days, respectively. According to the 2024 reimbursement catalog, the mean LOS for bimaxillary osteotomies (DRG D04A) in main hospital departments in 2023 was 5.3 days, compared to 4.3 days in affiliated departments ((InEK), 2024). The reported discharge timings in the study refer exclusively to ASA I patients, a low-risk group without comorbidities. Compared to the broader patient population included in INEK statistics – which encompasses cases such as OSAS and systemic illnesses – ASA I patients are expected to have shorter postoperative stays. This distinction likely explains the discrepancies between the survey responses and INEK data. Another explanation would be that self-reporting is underestimated without verification by the hospital information system.

While several authors describe series of outpatient OGS (Bergmann et al., 2023; Hattori et al., 2023; Pekkari et al., 2023), detailed analyses of the reasons for success or failure are often lacking (Prevost et al., 2023). Furthermore, significant differences exist between healthcare systems worldwide, which must not be overlooked (Rajan et al., 2021). Recommendations and decrees issued by local and national supervisory authorities influence the application of these procedures. In countries like Germany (Riekert et al., 2019), the United Kingdom (Garg et al., 2010), and Jordan (Jarab et al., 2012), OGS is predominantly performed in hospital settings. By contrast, initial reports of outpatient procedures come from Iceland (Bergmann et al., 2023), France (Prevost et al., 2023), Japan (Hattori et al., 2023), and the United States (Farrell and Tucker, 2014; Ferrara et al., 2022). However, outpatient OGS remains a relatively new practice that varies significantly between individual hospitals and countries. For instance, a survey-based study conducted in academic OMFS training centers in the U.S. reported that 85% of surgeons managed their patients postoperatively in inpatient settings, with discharge occurring on the first postoperative day (Bourne and Kinard, 2023). Through the continuous improvement of surgical and anesthetic procedures and their integration into protocols, which aim to achieve maximum synergy between pre-, intra-, and postoperative elements via

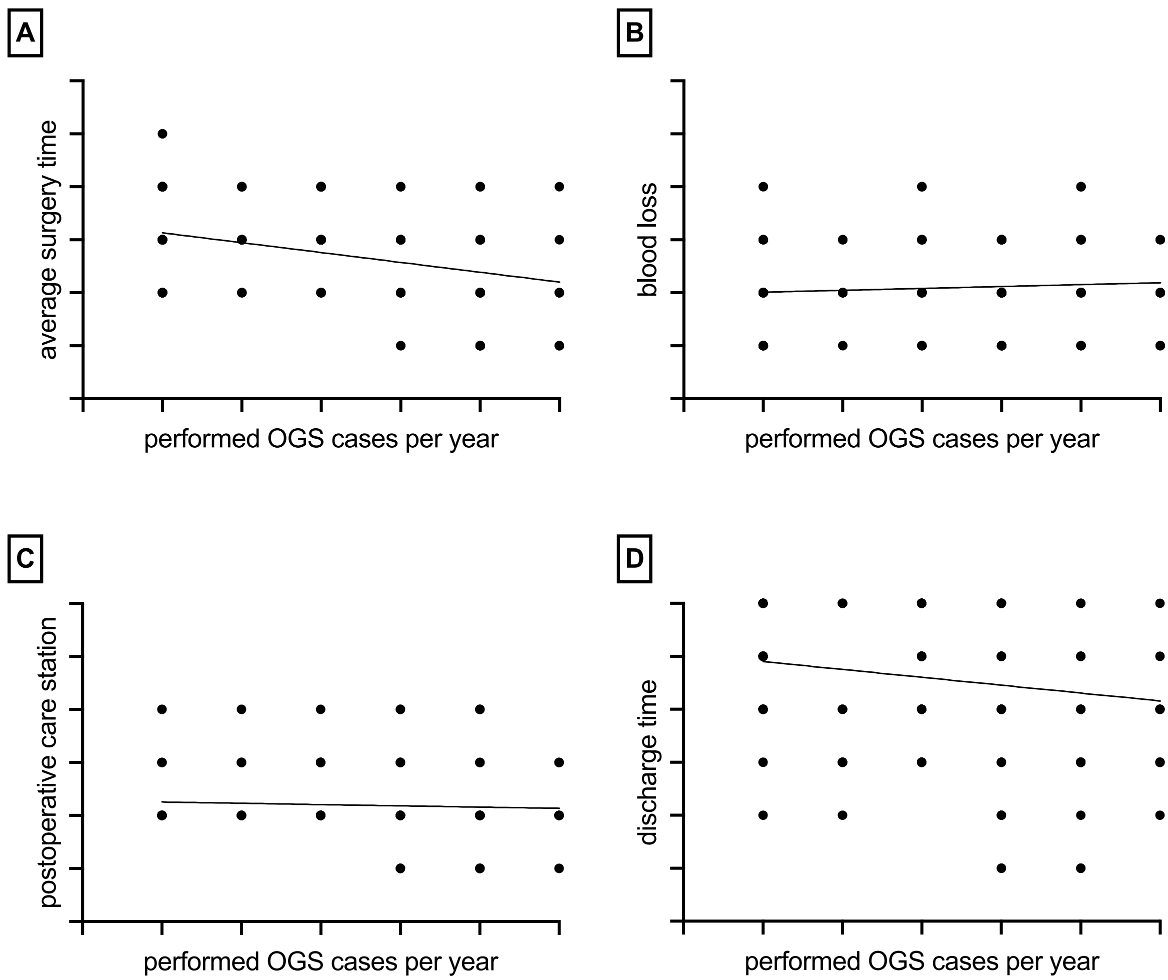

Fig. 2. Correlation Analysis of Annual Orthognathic Surgery Case Volume on Surgery Time, Blood Loss, Discharge Timing, and Postoperative Care Duration Scatter plots show relationships between annual OGS case volume and key outcomes. A significant moderate negative correlation was observed between "performed OGS cases per year" and both "surgery time" (A, $r = -0.4206$, $p < 0.001$) and "discharge time" (D, $r = -0.2134$, $p = 0.011$). No significant correlations were found with "blood loss" (B, $p = 0.276$) or "postoperative care station" (C, $p = 0.288$). Axes reflect ordinal scaling based on response options (see Supplementary Materials).

a multimodal approach, surgical stress can be reduced and patient recovery optimized (Patel et al., 2014; Bär et al., 2024). Across all surgical disciplines, there is strong evidence supporting improved patient outcomes using these protocols (Gustafsson et al., 2011; Nicholson et al., 2014; Group, 2015). Patients undergoing OGS also benefit from ERAS-based approaches, demonstrating fewer postoperative complications, less pain, and shorter LOS (Otero et al., 2017; Ferrara et al., 2022; Stratton et al., 2022; Hattori et al., 2023; Bär et al., 2024). Shorter LOS may not necessarily equate to outpatient treatment. Consistently, patient selection is emphasized as a critical component in the literature, relying on a careful benefit-risk assessment (Prevost et al., 2023).

Existing OGS protocols developed by individual authors or institutions represent a critical first step in the right direction, they still leave considerable room for improvement to be considered comprehensive and well-structured ERAS protocols (Bär et al., 2024). The substantial variability in perioperative practices observed among study participants supports Otero et al.'s observation that, despite proven benefits, surgeons often find it challenging to move away from traditional beliefs (Otero et al., 2017). Progress could be made by developing a comprehensive, consensus-based protocol through an expert panel, which could further optimize patient care in OGS (Bär et al., 2024). Within this framework, it is essential also to emphasize patient-reported outcomes (PROMs), which are currently underrepresented in existing studies.

The adoption of digital technologies such as CAD/CAM and patient-specific implants (PSI) has significantly transformed the field of OGS. Our findings show that 20% of respondents use digital methods exclusively, while 44.4% use a combination of digital and traditional techniques. However, 35.6% still rely exclusively on conventional methods. As highlighted by Naran et al., although PSI offers high precision and clinical utility, its widespread adoption is hindered by high costs and organizational challenges (Naran et al., 2018). This sentiment was echoed by survey participants, who also cited these issues as critical barriers to comprehensive implementation. Nevertheless, PSI and 3D-printed surgical guides continue to show promise in terms of accuracy and surgical outcomes. Studies by Li et al. and Diaconu et al. demonstrate how these technologies enable precise osteotomies and facilitate a waferless approach, deviating from traditional wafer-guided techniques (Diaconu et al., 2023; Li and Leung, 2023). Despite these advantages, a significant proportion of respondents (55.03%) still use wafers to secure postoperative occlusion, underscoring the need to bridge the gap between digital advancements and practical integration in routine clinical practice.

The survey revealed differences in surgical treatment strategies across institutions. Regarding surgical approaches, 54.09% of participants reported using the surgery-first approach, although

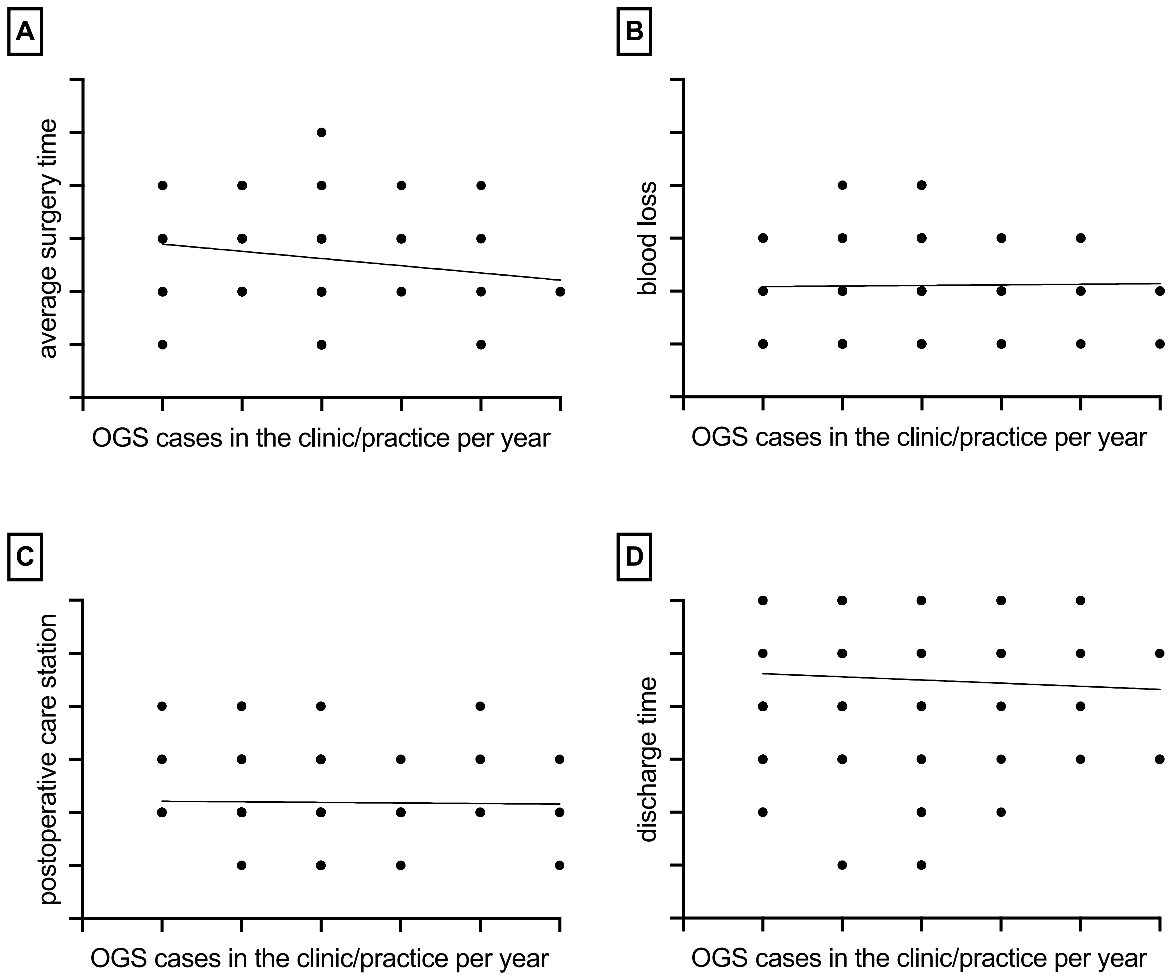

Fig. 3. Correlation Analysis of Annual Orthognathic Surgery Case Volume per Clinic on Surgery Time, Blood Loss, Discharge Timing, and Postoperative Care Duration
Scatter plots depict relationships between annual OGS case volume per clinic and key outcomes. A significant moderate negative correlation was identified between “performed OGS cases in the clinic or practice per year” and "surgery time" (A, $r = -0.1857$, $p = 0.022$). No significant correlations were found with "discharge time" (D, $p = 0.713$), "blood loss" (B, $p = 0.242$), or "postoperative care station" (C, $p = 0.621$). Axes reflect ordinal scaling based on response options (see Supplementary Materials).

predominantly in less than 10% of cases. With appropriate case selection, the surgery-first method has been proven to be an efficient and time-saving technique that significantly enhances patient satisfaction and long-term compliance (Peiró-Guijarro et al., 2016; Mahmood et al., 2018; Brucoli et al., 2019), while maintaining complication rates comparable to those of conventional OGS (Choi and Bradley, 2017; Mathew et al., 2020). However, the findings indicate a low acceptance rate, likely due to ongoing controversy regarding its long-term stability, which can be attributed to the limited literature comparing the two techniques (Mahmood et al., 2018; Seifi et al., 2018). Nevertheless, in carefully selected cases and with close collaboration between the surgeon and orthodontist, the disadvantages of not being able to use occlusion as a guide can be successfully mitigated (Hernández-Alfaro and Guijarro-Martínez, 2014; Mahmood et al., 2018; Mathew et al., 2020).

A preference for the maxilla-first approach (66% of respondents) aligns with the routine practice of bimaxillary surgery, as supported by literature, while the mandible-first sequence, despite its potential theoretical benefits, remains less common and dependent on the surgeon’s experience and specific case requirements (Borba et al., 2016; Borikanphanitphaisan et al., 2021; Andriola et al., 2024). The majority of respondents prefer to extract impacted or retained third molars at least six months before the OGS procedure, even though meta-analyses have shown that retaining third molars during mandibular sagittal split osteotomies, does not significantly increase the risk of complications, such as inferior alveolar nerve exposure or bad splits (Steenen et al., 2016; Filho et al., 2022). Moreover, Filho et al. suggest that the presence of third molars may even be associated with a reduced risk of nerve disorders (Filho et al., 2022). However, further high-quality studies are required to validate this observation.

The correlation analysis revealed a significant negative relationship between years of professional experience and average surgery time and discharge time, suggesting that more experienced surgeons perform procedures more efficiently, leading to earlier patient discharge. Similarly, the number of annual OGS cases a surgeon performs correlated negatively with surgery and discharge times, indicating that a higher case volume is associated with greater procedural efficiency. These findings are consistent with studies by Berlin et al. and Gupta et al., which demonstrate that high-volume hospitals discharge patients earlier, perform more complex procedures, and have lower complication rates (Berlin et al., 2016; Gupta et al., 2017). This emphasizes the importance of experience and case volume in optimizing surgical outcomes and highlights the need for targeted training and case allocation to enhance surgical competency.

Despite the valuable insights this survey provides, there are limitations typical of survey-based research. The survey was sent to all DGMKG members, meaning that non-members or members who did not subscribe to the newsletter were not reached. However, this approach allowed for capturing the perspectives of a broad range of surgeons, from residents to senior OMFS practitioners. Since the data is based on self-reporting and anonymized responses, there is potential for recall bias and variability in interpreting survey questions. Furthermore, the survey reflects a snapshot in time and may be influenced by the over-representation of university and non-university hospitals, which could skew findings toward practices more common in larger institutions. The absence of treatment outcome data limits the ability to assess the effectiveness of specific treatment modalities. Future studies should incorporate detailed outcome metrics to enable a more comprehensive evaluation.

5. Conclusion

This study demonstrated significant differences in OGS in OMFS in Germany. Possible causes can be attributed to facility-specific structures and organizational forms. Despite evidence supporting various perioperative management strategies, the application remains inconsistent. While a variety of approaches can lead to successful outcomes, the establishment of a standardized framework – such as the development of a guideline aligned with ERAS principles – could ensure more consistent, evidence-based care across all clinical settings and improve patient safety, satisfaction, and the effectiveness of these elective surgical procedures.

Ethical approval

Not required.

Data availability statement

All data supporting the findings of this study are included within the article. Supplementary Information files that further support these findings are available upon request from the corresponding author.

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Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcms.2025.03.004.

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