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Review

A call for fixed standards: a decade of orthognathic surgery, biting into revision rates and metalwork removal

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Abstract

The removal rate of titanium miniplates following orthognathic surgery varies widely (3.2–27.5%) due to inconsistent study designs and mixed samples. Plate removal is not routinely conducted in the UK. A 2019–2020 meta-analysis reported a 13.4% removal rate, though regular audits are uncommon. This study evaluates whether audit of local plate removal rates against established benchmarks merits encouragement. A retrospective review was conducted of orthognathic surgery at a tertiary centre (2014–2024). Procedures included Le Fort osteotomy, bilateral sagittal split osteotomy (BSSO), bimaxillary osteotomy (BIMAX), genioplasty, and other mandibular osteotomies. All patients received two postoperative doses of dexamethasone and intravenous antibiotics. Data collected included demographics, smoking status, surgical site, re-plating, and antibiotic use. The primary outcome was return to theatre (RTT) for plate removal or replacement. Chi squared, Fisher's exact, and binomial tests were used to assess statistical significance. Over 10 years, 417 patients underwent 429 orthognathic procedures, including 12 revisions to achieve the desired skeletal and orthodontic outcome. Overall, metalwork removal/adjustment occurred in 46 cases, predominantly within the first year, with infection identified as the leading cause. The removal rate was 10.7% (46/429), consistent with the 13.4% benchmark ($p = 0.12$). Yearly rates generally aligned with the benchmark, except in 2021, when deviations were likely to have been influenced by COVID-19-related disruptions. Smoking ($p = 1.0$) and oral antibiotics on discharge ($p = 0.09$) were not significantly associated with plate removal rates. These findings validate the 13.4% benchmark for metalwork removal. Routine audit and inter-unit collaboration are vital for refining benchmarks and improving patient care.

Keywords: Orthognathic surgery; Bilateral sagittal split osteotomy (BSSO); Bimaxillary osteotomy; Metalwork removal; Hardware removal; Surgical outcomes; Complications; Standardisation

Introduction

Titanium miniplates are the standard for internal fixation in orthognathic surgery due to their biocompatibility, strength, and stability.[1] Although intended to remain in situ, removal is sometimes required, most commonly for infection, exposure, discomfort, or relapse.[1] Reported removal rates range from 3.2% to 27.5%, reflecting variation in case mix, fixation systems, follow-up duration, and outcome definitions.[1]

In a systematic review and meta-analysis of 19 studies including large UK cohorts (for example, Widar et al), Gómez-Barrachina et al reported an overall patient-level removal rate of 13.4%, proposed as an audit benchmark.[1] However, substantial heterogeneity, particularly in indications for removal and follow up, limits its precision for UK service benchmarking; no pooled UK-specific benchmark currently exists.[1] The 13.4% estimate therefore provides useful context but requires cautious application in UK service evaluation and governance.

The 2013 UK Commissioning Guide for Orthognathic Procedures identifies hardware removal as a postoperative

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complication, but captures it only through local audit without national benchmarking or central reporting.[2] This contributes to variable practice, inconsistent patient counselling, and limited understanding of modifiable risk factors. Revision surgery also consumes theatre capacity, increases morbidity, and adds financial pressure, complicating service planning.

This 10-year review of orthognathic procedures at a high-volume UK tertiary centre provides robust longitudinal data to evaluate the applicability of the 13.4% benchmark within a UK context. By analysing local removal rates, temporal trends, and contributory factors, it demonstrates how routine audit can strengthen governance, inform service planning, and support the development of national standards.[1,2]

Methods

A retrospective review was conducted of all orthognathic surgeries performed at a UK tertiary centre between January 2014 and January 2024, including Le Fort I osteotomy, bilateral sagittal split osteotomy (BSSO), bimaxillary (BIMAX) surgery, genioplasty, and other mandibular osteotomies. Procedures were consultant-led with trainee involvement, reflecting the unit's role as a recognised training centre. Planned revisions for occlusal or skeletal optimisation were included, and the review was registered as a service evaluation in accordance with institutional requirements.

Rigid internal fixation used low-profile, off-the-shelf titanium plates (Synthes/Synthes Matrix; commercially pure titanium, ASTM F67 Grade 2). No patient-specific or custom-manufactured systems were used. Mandibular fixation typically comprised two 0.8 mm L-shaped plates with monocortical screws (5–6 mm), with alternative plates used selectively for complex splits. Maxillary fixation usually involved three to four 0.7–0.8 mm plates at the piriform rim and zygomaticomaxillary buttresses.

Perioperative care comprised two postoperative intravenous dexamethasone doses and prophylactic intravenous antibiotics, with oral antibiotics prescribed at discharge at the surgeon's discretion.

Electronic records, operative notes, and radiographs provided demographics, smoking status, surgical site(s), and outcomes. The primary outcome was return to theatre (RTT) for titanium plate/screw removal or replacement. Exclusions were RTT for wire removal only, surgically-assisted rapid palatal expansion (SARPE)-only procedures, or cases under local anaesthetic.

Indications for metalwork removal were classified from contemporaneous clinical documentation as infection, discomfort, unintended aesthetic outcomes, unmet occlusal or skeletal goals, interference with planned surgery, reactive tissue or cystic changes, or hardware failure. Failed metalwork was defined as mechanical or functional fixation failure requiring removal or revision (for example, plate or screw loosening, migration, deformation, or exposure), excluding infection-related removal. Interference with planned surgery referred to hardware impeding access to revision or optimisation procedures (for example, within the surgical field of septorhinoplasty), while unintended aesthetic outcomes described hardware-related contour changes (for example, nasal flaring) and unmet occlusal or skeletal outcomes denoted clinically significant relapse or occlusal change.

Plate removal rates were calculated at the procedure level, defined as RTT for plate and/or screw removal or adjustment rather than per individual plate. Descriptive statistics summarised patient characteristics and removal rates. Categorical associations were assessed using chi squared or Fisher's exact tests. A binomial test compared the observed removal rate with the 13.4% benchmark reported by Gómez-Barrachina et al[1] ($p < 0.05$ = significant; $p > 0.05$ = aligned). IBM SPSS Statistics for Windows version 26 (IBM Corp) was used for all analyses.

Results

Patient demographics and overall return to theatre rate

Between January 2014 and January 2024, 417 patients underwent 429 orthognathic procedures, including 12 planned revisions for skeletal/occlusal optimisation. Forty-six procedures (10.7%) required RTT for metalwork removal or adjustment, typically involving both plates and screws. In one case, only screws were removed due to complete plate osseointegration; in two cases, plates were recontoured or partially sectioned, and were retained in the analysis.

The cohort included 217 females and 200 males; RTT occurred in 22 females (10.1%) and 19 males (9.5%) (OR: 1.07, 95% CI: 0.55 to 2.09, p = 0.87).

By age, most cases were 18–24 years old (n = 22/251), with the highest proportional rate in those aged 35–44 years (n = 2/22). Three of 124 cases occurred in the 25–34-year age group; none in those under 18 years (n = 8) or aged 45–54 years (n = 8). No patients aged ≥55 years underwent orthognathic surgery. Age band analysis showed no significant association (p = 0.21), but grouping into age <25 versus ≥25 years showed a higher removal risk in younger patients (OR = 2.84, p = 0.04).

Of 76 patients with cleft lip and/or palate, five underwent removal versus 36/341 non-cleft patients (OR = 0.60, p = 0.40).

Return to theatre (RTT): frequency, timing, and indications

A total of 46 RTT procedures were performed: 37 patients underwent one, three patients two, and one patient three. This yielded 41 first returns (RTT1), four second returns (RTT2), and one third return (RTT3); no patient exceeded three.

For RTT1 (Table 1), most occurred within 24 months, peaking at 7–12 months (n = 11). Early returns (<6 months) accounted for eight cases, with a smaller peak at 25–36 months (n = 6); five occurred after 36 months. Stratification by follow-up interval (Fig. 1) showed that at the 7–12-month peak (n = 11), infection (n = 5) and discomfort (n = 5) predominated. Of the four RTT2, three occurred at 7–12 months

Table 1
Timing of first return to theatre (RTT1). Data are number of patients.

Months postoperatively	Frequency
0–1	2
2–3	2
4–6	4
7–12	11
13–18	8
19–24	3
25–36	6
37–48	1
49–60	2
>60	2
Total	41

and one at >60 months; the single RTT3 occurred at 61 months for persistent discomfort.

Across all RTTs, 59 indications were recorded, with 13 patients having multiple reasons (Table 2). Infection was most common (n = 21), followed by discomfort (n = 12), failed metalwork (n = 12), and occlusal/skeletal issues (n = 6). Less frequent were interference with planned surgery (n = 3), reactive/cystic changes (n = 2), and unintended aesthetic outcomes (n = 2). One patient requested removal without clinical indication due to neurodiversity. Later-stage RTTs were rare and typically linked to persistent symptoms or patient-specific factors.

Site of metalwork removal

Removals involved the maxilla in 25 procedures, the mandible in 19, and both jaws in two, with significantly greater maxillary involvement (χ^2 = 18.57, $p < 0.001$). Stratified by anatomical site, mandibular procedures yielded 28 indica-

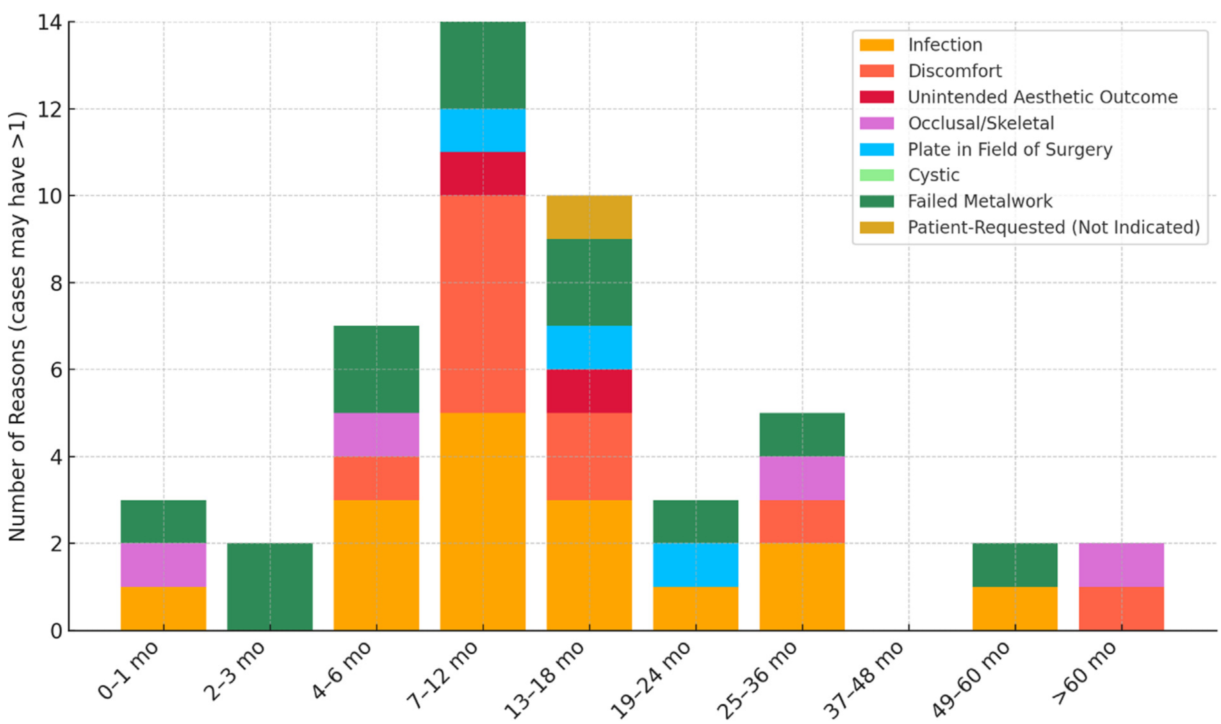

Fig. 1. Timing of metalwork removal (months) or adjustment causes at first return to theatre (RTT1). Cases are stratified by postoperative interval. Infection and discomfort predominated at the 7–12-month peak. Multiple causes could be recorded for a single case. RTT1 = first return to theatre.

Table 2
Reasons for metalwork removal or adjustment by type of return to theatre (RTT). Data are number of cases.

Reason	RTT1 (first return)	RTT2 (second return)	RTT3 (third return)
Infection	19	2	0
Discomfort	11	0	1
Unintended facial aesthetic outcomes	2	0	0
Occlusal/skeletal issues	5	1	0
Plate in field of additional surgery	2	1	0
Reactive/cystic changes to plate	1	1	0
Failed metalwork	10	2	0
Patient request (not indicated)	1	0	0
Total	51	7	1

Multiple reasons could be recorded for a single case.

tions, 27 maxillary procedures, and four both-jaw procedures, accounting for all recorded indications.

Among mandibular procedures (n = 19), infection predominated (n = 14), followed by failed metalwork (n = 7) and discomfort (n = 6). Occlusal or skeletal indications were rare (n = 1), with no mandibular removals for aesthetic, reactive, or access-related indications. Bilateral mandibular plate removal was uncommon (n = 4), occurred exclusively at the first return to theatre, and was associated with infective or mixed indications.

In contrast, maxillary procedures (n = 25) showed a broader indication profile, including infection (n = 7), discomfort (n = 6), unmet occlusal or skeletal outcomes (n = 5), failed metalwork (n = 4), interference with additional surgery (n = 2), reactive or cystic changes (n = 2), and unintended aesthetic outcomes (n = 1). Bilateral maxillary removal was more frequent, while isolated single-plate removal occurred in nine RTT procedures, typically for localised indications such as plate or screw exposure, focal infection, reactive change, or interference with dental or surgical procedures.

Metalwork removal rates compared with the 13.4% benchmark

Across the 10-year study period, 46 of 429 orthognathic procedures required metalwork removal, giving an overall removal rate of 10.7%, which was not significantly different from the published 13.4% benchmark ($p = 0.12$). Annual removal rates ranged from 5.7% (2014 and 2015) to 30.8% (2021). In most years, the rates remained below the benchmark, with the exception of 2021, which demonstrated a

Table 3
Annual orthognathic procedures, metalwork removals, and comparison with the published 13.4% benchmark. Annual removal rates were compared with the published 13.4% benchmark. Data from January 2024 (3 new procedures, 5 removals from prior cases) were excluded from annual comparisons but included in the overall total.

Year	No. of procedures	No. of removals	Removal rate (%)
2014	53	3	5.7
2015	53	3	5.7
2016	49	4	8.2
2017	42	3	7.1
2018	45	6	13.3
2019	46	5	10.9
2020	17	2	11.8
2021	13	4	30.8
2022	50	6	12.0
2023	58	5	8.6
2024 (Jan only)*	3	5	—
Total (2014–2024 Jan only)	429	46	10.7

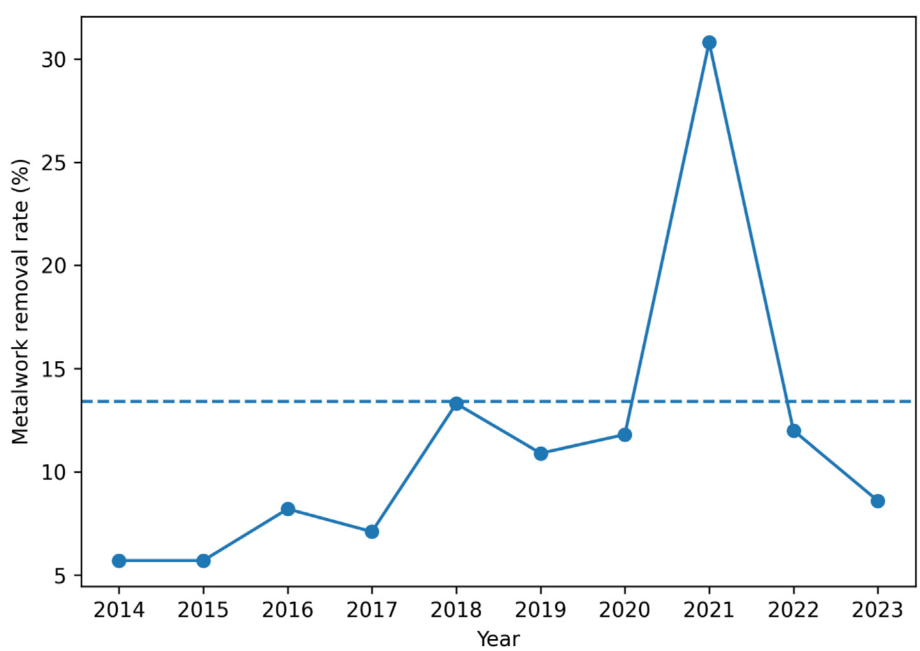

Fig. 2. Annual removal rates compared with the 13.4% benchmark 2012–2023. The solid blue line represents the annual metalwork removal rate, while the dashed blue line indicates the published benchmark of 13.4%. Data from 2024 were excluded from annual comparisons as this represented a partial year.

marked deviation. Three procedures performed in January 2024 were included in the overall case count (n = 429); however, as this represented a partial year, 2024 was excluded from the annual comparisons. Annual case volumes and removal rates are summarised in Table 3 and illustrated in Fig. 2.

Infection-related plate removal: association with smoking and antibiotic use

Smoking status was available for 275 patients (35 smokers, 240 non-smokers). Infection-related plate removal occurred in 2/35 smokers and 14/240 non-smokers, with no significant association (OR 0.98, 95% CI 0.21 to 4.50; Fisher's exact test, $p = 1.00$) (Table 4).

Postoperative oral antibiotic use was recorded in 417 patients, of whom 135 (32%) received antibiotics and 282 (68%) did not. Infection-related removal occurred in three of 135 patients prescribed antibiotics (2.2%) and 18/282 patients not prescribed antibiotics (6.4%), with no significant association (OR 0.33, 95% CI 0.10 to 1.15; Fisher's exact test, $p = 0.09$) (Table 4). Although infection rates were lower with antibiotic use, this trend did not reach statistical significance.

Discussion

Overview of findings and contextualisation

This 10-year retrospective review identified a titanium plate removal rate of 10.7%, consistent with international ranges and not significantly different from the 13.4% meta-analytical benchmark reported by Gómez-Barrachina et al ($p = 0.12$).[1] Although widely cited, this benchmark has recognised methodological limitations, notably its search strategy and funnel plot interpretation, necessitating caution when generalising across surgical contexts.[1] By contrast, Jaber et al reported a lower pooled rate of 5.3% based on symptomatic removals only, likely underestimating the true clinical burden.[3] For institutional quality assurance, the broader 13.4% benchmark therefore remains preferable.

The elevated removal rate in 2021 (30.8%) coincided with COVID-19–related service disruption, including delayed presentation, surgical backlog, and restricted follow up. Comparable impacts on oral and maxillofacial surgery have been reported in UK studies, such as reduced elective activity, treatment delays, and altered case mix,[4–6] and globally across surgical disciplines.[7–9] These fluctuations reinforce the importance of routine audit to identify outliers, monitor recovery, and support service planning.

Demographic influences on removal rates

RTT rates did not differ significantly between females (10.1%) and males (9.5%), consistent with reports of minimal gender-based variation in miniplate removal.[1,3,10] Although Adatia et al observed a female predominance (68%) among removals, this likely reflects demographic or referral patterns rather than biological risk.[10]

The greatest number of RTT cases occurred in 18–24-year-olds, the age group in which most orthognathic surgery is performed after skeletal maturity. Younger patients, often motivated by aesthetic or occlusal concerns, may have greater symptom awareness, longer follow up, and lower tolerance for retained hardware, increasing the likelihood of removal.[11,12] Older adults more commonly undergo surgery for functional indications such as obstructive sleep apnoea and therefore represent a smaller proportion of cases.[12]

Proportionally, RTT was highest in the 35–44-year group, suggesting increased per-capita risk despite fewer total cases.[12] Higher complication rates in older patients have been linked to reduced bone healing, comorbidities, and diminished physiological reserve.[11,12] The absence of RTT in patients ages <18 or >54 years likely reflects lower intervention rates and higher revision thresholds.

Overall, age-specific trends were not statistically significant ($p = 0.21$), consistent with the finding by Lee et al that age alone is not associated with increased perioperative complications.[13] However, small numbers, particularly in patients aged $\geq$45 years, may limit interpretation. A simplified analysis demonstrated a significantly higher likelihood of a RTT in patients aged <25 years (OR = 2.84, $p = 0.04$), consistent with reports of increased revision risk in younger patients.[11,12] These findings support age-tailored counselling to address differing risk profiles, motivations, and expectations.

Table 4
Infection-related plate removals by smoking status and antibiotic use on discharge.

Category	Infection removals (%)	OR	95% CI	p value
Smokers	2/35 (5.7)	0.98	0.21 to 4.50	1.00*
Non-smokers	14/240 (5.8)	Reference	—	—
Antibiotics:				
Yes	3/13 (2.2)	0.33	0.10 to 1.15	0.09*
No	18/282 (6.4)	Reference	—	—

* Fisher's exact test.

Cleft vs non-cleft patient outcomes

The lower hardware removal rate in cleft patients compared with non-cleft patients aligns with evidence that multidisciplinary cleft care, including early orthodontic intervention and structured follow up, can reduce long-term surgical burden.[10,14,15] Population-based studies have reported low orthognathic surgery rates in cleft cohorts, attributed to regional cleft patterns, early orthodontic stimulation, and optimised surgical timing.[15] However, this association was not statistically significant in the present cohort (OR = 0.60, p = 0.40). Reported outcomes remain heterogeneous, with some studies identifying higher complication rates in cleft patients[16] and others highlighting the influence of anatomical severity and dental agenesis.[17] Given the modest cleft sample, these findings warrant cautious interpretation, and validation in larger multicentre studies.

Timing and indications for removal

Consistent with existing literature, most hardware removals in our cohort occurred within 24 months of orthognathic surgery, with a peak between 7 and 12 months.[1,10,18,19] This mirrors previous reports, including a retrospective series in which 57% of removals occurred within this window, with extremes ranging from seven weeks to almost five years postoperatively,[10] and the finding by Falter et al of a mean removal time of 9.9 months.[19] Infection was the most common indication in our series, aligning with published rates of 12% – 63%, followed by discomfort, hardware failure, and relapse.[20]

Histopathological studies by Armencea et al reveal fibrous encapsulation, titanium debris, and foreign-body giant cell reactions around hardware even without overt infection, supporting the clinical spectrum of hardware-related complications.[21]

Anatomical site of removal

A statistically significant predominance of maxillary over mandibular hardware removals was observed ($\chi^2 = 18.57$, $p < 0.001$), contrasting with Little et al who reported higher mandibular removal rates attributed to greater biomechanical stress and reduced vascularity.[22] Although higher OR (≈ 1.2–1.5) for mandibular removal were reported, statistical significance was inconsistent.[1,3] Anatomical factors such as sinus proximity and maxillary bone variability may increase maxillary risk,[11] while surgical sequencing and stability hierarchies may influence relapse and complication rates.[23,24] These findings support site-specific audit and risk assessment incorporating both anatomical and technical factors.

Differences in bilateral plate removal between the mandible and maxilla appear to reflect anatomical context and fixation strategy rather than uniform failure mechanisms. Bilateral mandibular removal was rare, occurred early postoperatively, and was predominantly infection-related.[22] In contrast, bilateral maxillary plate removal is likely to reflect routine multiplate fixation and en bloc removal following Le Fort I osteotomy rather than bilateral pathology.[25] Selective single-plate removal for focal indications highlights the pragmatic management of maxillary hardware. These findings underscore the importance of interpreting laterality at the procedure level, as bilateral or multiplate removals often represent a single clinical episode rather than independent hardware failures.

Infection, smoking, and antibiotic use

Infection was the principal indication for hardware removal, consistent with orthognathic surgery literature. No significant association was observed between smoking status and infection-related RTT, aligning with findings by Abdul Wahab et al, who reported no independent predictive effect of smoking in single-piece osteotomy cases,[26] and Cousin et al, whose 10-year review also found no association with long-term hardware complications.[27] Although smoking is a recognised infection risk in maxillofacial trauma and implant surgery,[27] these findings suggest a multifactorial aetiology in elective orthognathic contexts. The absence of pack-year data limited dose–response analysis.

Perioperative antibiotic prophylaxis is well established; however, the benefit of routine oral antibiotics at discharge remains uncertain. In this cohort, postoperative antibiotic prescribing was discretionary, reflecting real-world practice. A non-significant trend towards reduced infection-related plate removal was observed, consistent with Naros et al, who found no benefit beyond 24 hours of prophylaxis, and Remschmidt et al, who reported comparable outcomes between prolonged and single-dose regimens.[28,29] Cousin et al further emphasised that infection risk is more strongly influenced by surgical technique and host factors than prophylaxis duration.[27] Reporting variation in surgeon-level prescribing may therefore support audit, benchmarking, and stewardship-guided antibiotic use.

Study limitations and clinical implications

The retrospective design, incomplete data capture, and lack of adjustment for surgical complexity or plate-specific factors limit causal interpretation. Small subgroup sizes limited age-based and formal statistical comparisons. Annual comparisons were undertaken despite denominators of <100, as percentage-based benchmarking against the 13.4% literature standard was required and may imply spurious precision. Larger samples would better confirm yearly applicability but may not be feasible within single-centre volumes. Single-manufacturer fixation limited assessment of material heterogeneity; nonetheless, this large UK single-centre dataset provides valuable insight to inform counselling, outcome reporting, and strategies to reduce hardware removal.

Conclusion

This study is one of the few UK-based 10-year analyses of titanium plate removal after orthognathic surgery, reporting a 10.7% removal rate consistent with international benchmarks. It is distinctive in directly evaluating the applicability of the published 13.4% benchmark to UK practice, contributing to efforts to establish a standardised framework for reporting and comparison. The findings underscore the value of routine audit and inter-centre comparison in clinical governance, and the need for systematic monitoring and multicentre collaboration to refine benchmarks and drive quality improvement across the NHS.

Conflict of interest

We have no conflicts of interest.

Ethics approval

Not required

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