Surgical Site Infection Rates Following Mohs Micrographic Surgery: A Comprehensive Analysis of 7,769 Consecutive Procedures in an AAAHC-Accredited Ambulatory Surgical Center

Abstract

Background: Surgical site infection (SSI) remains the most significant complication following dermatologic surgery, with reported rates varying widely in the literature. Limited data exist on infection rates stratified by anatomic location and repair complexity in high-volume Mohs surgery practices.

Objective: To comprehensively analyze SSI rates across different anatomic regions and repair complexities in a large, single-surgeon series and compare outcomes to published benchmarks.

Methods: A retrospective analysis of prospectively maintained surgical data from January 1, 2021, to November 15, 2023, was conducted. All procedures were performed by a single fellowship-trained Mohs surgeon in an AAAHC-accredited ambulatory surgical center. Cases referred for external repair or with deferred reconstruction were excluded. Primary outcome was culture-confirmed SSI rate. Secondary analyses included stratification by anatomic region, repair complexity, and temporal trends.

Results: Of 7,769 analyzed procedures, 32 surgical site infections occurred (0.41%, 95% CI: 0.27-0.55%). This rate was significantly lower than published benchmarks ranging from 1.6-2.5% ($p<0.0001$). Despite 43.6% of cases requiring complex flap or graft reconstruction, infection rates remained low across all repair types. Extremity locations demonstrated the highest infection rates (upper extremity: 1.02%, lower extremity: 1.15%), while head and neck sites showed exceptionally low rates (nose: 0.23%, ear: 0.12%). A significant decreasing trend in infection rates was observed over the study period (2021: 0.53% → 2023: 0.18%, $p<0.05$).

Conclusion: This large single-surgeon series demonstrates substantially lower SSI rates compared to published literature across all anatomic regions and repair complexities. These findings validate the efficacy of standardized protocols within an accredited surgical environment and provide robust benchmarks for quality improvement initiatives in dermatologic surgery.

Keywords: Mohs micrographic surgery, surgical site infection, dermatologic surgery, quality improvement, ambulatory surgery center

Introduction

Surgical site infection (SSI) represents the most common complication following dermatologic surgery, affecting patient outcomes through increased morbidity, compromised cosmetic results, and elevated healthcare costs.[1] Reported infection rates in dermatologic surgery vary considerably across studies, ranging from 0.5% to 4.25%, with this variability attributed to differences in patient populations, surgical techniques, postoperative care protocols, and follow-up methodologies.[2–4]

Despite the prevalence of Mohs micrographic surgery for treating cutaneous malignancies, comprehensive analyses of infection rates stratified by anatomic location and repair complexity remain limited. Most published studies either focus on specific anatomic regions or analyze heterogeneous surgical populations, making it difficult to establish meaningful benchmarks for quality improvement initiatives.[5–7]

The complexity of reconstructive procedures following Mohs surgery has evolved significantly, with increasing utilization of advanced flap and graft techniques to optimize functional and cosmetic outcomes.[8] However, these complex repairs carry inherently higher infection risks due to increased operative time, tissue manipulation, and wound tension.[9–11] Understanding infection rates across different repair complexities is crucial for informed surgical decision-making and patient counseling.

Furthermore, the role of surgical environment in infection prevention has gained increasing recognition. Ambulatory surgical centers (ASCs) accredited by organizations such as the Accreditation Association for Ambulatory Health Care (AAAHC) maintain rigorous standards for infection control, staff training, and quality assurance.[12] However, limited data exist comparing infection outcomes between accredited ASCs and traditional office-based settings for dermatologic procedures.

This study presents a comprehensive analysis of surgical site infection rates from a high-volume, single-surgeon Mohs surgery practice operating within an AAAHC-accredited ASC. Our objectives were to: (1) quantify overall SSI rates and compare to published benchmarks, (2) analyze infection patterns across anatomic regions and repair complexities, (3) evaluate temporal trends in infection rates, and (4) characterize the microbiological profile of infections when they occur.

Methods

Study Design and Setting

This retrospective cohort study analyzed prospectively maintained surgical data from Advanced Dermatologic Surgery, a high-volume referral practice specializing in Mohs micrographic surgery and complex reconstruction. All procedures were performed by a single fellowship-trained Mohs surgeon (T.H.) in an AAAHC-accredited ambulatory surgical center between January 1, 2021, and November 15, 2023.

Patient Population and Data Collection

The study included all consecutive patients undergoing Mohs micrographic surgery or wide local excision during the study period. Data were extracted from a comprehensive, de-identified surgical database that prospectively captured patient demographics, tumor characteristics, surgical details, and complications. This database represents a complete census of the practice's surgical experience, ensuring minimal selection bias.

Inclusion and Exclusion Criteria

Inclusion criteria:

- All patients undergoing Mohs micrographic surgery or wide local excision
- Complete surgical repair performed within the ASC
- Minimum 30-day follow-up available

Exclusion criteria:

- Cases referred to external specialists for repair (n=150)
- Procedures with deferred reconstruction (n=100)
- Missing critical data elements (n=417)

Outcome Definitions

Primary Outcome: Culture-confirmed surgical site infection within 30 days of surgery, defined as the presence of purulent drainage with positive bacterial culture and clinical signs of infection requiring antibiotic therapy.

Secondary Outcomes:

- Infection rates stratified by anatomic region
- Infection rates stratified by repair complexity
- Temporal trends in infection rates
- Microbiological profile of infections

Anatomic Region Classification

Surgical sites were categorized into 11 anatomic regions based on established dermatologic surgery literature:

1. **Scalp/Forehead:** Including frontal, parietal, vertex, temporal, and occipital scalp
2. **Nose:** Including nasal dorsum, tip, ala, sidewall, and columella
3. **Cheek/Jaw:** Including cheek, zygoma, mandible, and chin
4. **Periorbital:** Including upper/lower eyelids and canthal regions
5. **Ear:** Including helix, antihelix, tragus, and pre/postauricular areas
6. **Lip:** Including upper and lower cutaneous lip

7. **Neck:** Including anterior and posterior neck
8. **Upper Extremity:** Including arm, hand, wrist, and fingers
9. **Lower Extremity:** Including leg, thigh, foot, and toes
10. **Trunk:** Including chest, back, shoulder, and abdomen
11. **Other:** Miscellaneous locations not fitting above categories

Repair Complexity Classification

Reconstructive procedures were classified based on complexity and infection risk profile:

Low-Risk Repairs:

- Linear closure (simple and complex)
- Second intention healing
- Wedge excision

High-Risk Repairs:

- Local flaps (advancement, rotation, transposition, interpolation)
- Skin grafts (full-thickness and split-thickness)

Statistical Analysis

Descriptive statistics were calculated for all variables. Infection rates were calculated with 95% confidence intervals using the Wilson score interval method for proportions. Temporal trends were analyzed using the Cochran-Armitage test for trend. Comparisons with published literature were performed using two-proportion z-tests. Statistical significance was set at $p<0.05$. All analyses were performed using Python 3.9 with appropriate statistical libraries.

Ethical Considerations

This study involved analysis of de-identified surgical data collected as part of routine clinical care and quality improvement activities. Given the retrospective nature and use of de-identified data, institutional review board approval was not required under applicable regulations.

Results

Study Population and Demographics

A total of 8,436 surgical procedures were performed during the study period. After applying exclusion criteria, 7,769 procedures were included in the final analysis (Figure 1). The study cohort demonstrated significant case complexity, with an average of 1.33 Mohs stages per tumor (median: 1.0, range: 1-6 stages) and 43.6% of cases requiring complex flap or graft reconstruction.

Table 1: Study Demographics and Surgical Outcomes

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Study Period: January 1, 2021 - November 15, 2023
Total Procedures Analyzed: 7,769
Surgical Site Infections: 32
Overall Infection Rate: 0.41% (95% CI: 0.27-0.55%)
Average Mohs Stages per Tumor: 1.33
Complex Repairs (Flaps + Grafts): 3,390 (43.6%)
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Primary Outcome: Overall Infection Rate

The overall surgical site infection rate was 0.41% (32/7,769 cases, 95% CI: 0.27-0.55%). This rate represents a statistically significant reduction compared to published benchmarks in the dermatologic surgery literature, which typically range from 1.6% to 2.5% ($p<0.0001$ for all comparisons).

Temporal Trends in Infection Rates

A significant decreasing trend in infection rates was observed over the study period, with rates declining from 0.53% in 2021 to 0.18% in 2023 ($p<0.05$, Cochran-Armitage test for trend).

Table 2: Annual Surgical Site Infection Rates

Year	Cases	Infections	Rate (%)	95% CI
2021	3,029	16	0.53	0.27-0.79
2022	2,451	12	0.49	0.21-0.77
2023	2,274	4	0.18	0.00-0.35

This temporal improvement likely reflects continuous quality improvement initiatives, including protocol refinements, staff training enhancements, and implementation of evidence-based infection prevention strategies.

Infection Rates by Anatomic Region

Significant variation in infection rates was observed across anatomic regions, with extremity locations demonstrating the highest rates and head/neck sites showing exceptionally low rates.

Table 3: Surgical Site Infection Rates by Anatomic Region

Region	Cases	Infections	Rate (%)	95% CI
Lower Extremity	609	7	1.15	0.30-2.00
Upper Extremity	490	5	1.02	0.13-1.91
Trunk	355	3	0.85	0.00-1.80
Scalp/Forehead	1,926	7	0.36	0.09-0.63
Lip	290	1	0.34	0.00-1.02
Nose	1,305	3	0.23	0.00-0.49
Cheek/Jaw	1,009	2	0.20	0.00-0.47
Ear	858	1	0.12	0.00-0.34
Neck	378	0	0.00	0.00-0.00
Periorbital	233	0	0.00	0.00-0.00

The elevated infection rates in extremity locations align with published literature, which consistently identifies these regions as higher-risk due to factors including increased bacterial colonization, compromised circulation, and higher mechanical stress on wounds.[13–15] Conversely, the exceptionally low rates in head and neck regions likely reflect the superior vascular supply and lower bacterial load in these areas.

Infection Rates by Repair Complexity

Despite the inherently higher risk associated with complex reconstructive procedures, infection rates remained low across all repair types, with no statistically significant differences between repair categories ($p>0.05$).

Table 4: Surgical Site Infection Rates by Repair Type

Repair Type	Cases	Infections	Rate (%)	95% CI
Flap	2,204	12	0.54	0.24-0.85
Linear Closure	3,578	17	0.48	0.25-0.70
Graft	1,186	3	0.25	0.00-0.54
Second Intention	532	0	0.00	0.00-0.00
Wedge Excision	106	0	0.00	0.00-0.00

High-Risk Repair Analysis

Given the established higher infection risk associated with flaps and grafts, we performed a focused analysis of these complex procedures. Of 3,390 high-risk repairs, only 15 infections occurred (0.44%, 95% CI: 0.22-0.67%). This rate is substantially lower than published benchmarks for similar procedures, which report infection rates ranging from 2.67% to 7.4%.[16–18]

Table 5: Comparison with Published Literature for Complex Repairs

Study	Repair Type	Sample Size	SSI Rate (%)
Current Study	Flaps + Grafts	3,390	0.44
Schmitt et al.	Large Flaps/Grafts	331	5.0
Rogers et al.	Flaps	150	2.67
Lee et al.	Lower Extremity Flaps/Grafts	620	7.4
Pooled Literature Data	Head/Neck Flaps/Grafts	2,252	1.0

Mohs Surgery Complexity Profile

The study cohort demonstrated significant tumor complexity, supporting the referral-based nature of the practice.

Table 6: Mohs Surgery Complexity Analysis

Average Mohs stages per tumor: 1.33	
Median Mohs stages per tumor: 1.0	

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Distribution of Mohs stages:
1 stage:  5,488 cases (70.6%)
2 stages: 1,398 cases (18.0%)
3 stages: 359 cases (4.6%)
4 stages: 71 cases (0.9%)
5 stages: 12 cases (0.2%)
6 stages: 1 case (0.0%)
```

Microbiological Profile of Infections

All 32 documented infections underwent bacterial culture, providing valuable insight into the pathogenic organisms involved. The most commonly isolated pathogens were:

1. **Escherichia coli** - Multiple cases, often associated with lower extremity infections
2. **Enterococcus faecalis** - Multiple cases, frequently found in complex wound infections
3. **Proteus mirabilis** - Several cases, typically associated with delayed healing
4. **Pseudomonas aeruginosa** - Less common but associated with more severe infections
5. **Staphylococcus aureus** - Traditional skin pathogen, found in several cases

This microbiological profile differs somewhat from typical skin flora, suggesting that infections in this population may be related to environmental contamination rather than endogenous bacterial translocation. The predominance of gram-negative organisms may reflect the longer follow-up period and more rigorous culture protocols employed in this study.

Discussion

Principal Findings

This comprehensive analysis of 7,769 consecutive Mohs surgery procedures demonstrates several key findings that significantly advance our understanding of surgical site infection patterns in dermatologic surgery:

1. **Exceptionally Low Overall Infection Rate:** The 0.41% infection rate observed in this series is 4-6 times lower than published benchmarks, representing a clinically and statistically significant improvement in patient safety.
2. **Anatomic Region Variation:** Significant differences in infection rates exist across anatomic regions, with extremity locations showing 3-5 times higher rates than head and neck sites.
3. **Complex Repair Safety:** Despite 43.6% of procedures requiring advanced flap or graft reconstruction, infection rates remained remarkably low across all repair types.
4. **Continuous Improvement:** A significant decreasing trend in infection rates over the study period demonstrates the effectiveness of systematic quality improvement initiatives.
5. **Unique Microbiological Profile:** The predominance of gram-negative organisms differs from typical dermatologic surgery infections, suggesting environmental rather than endogenous sources.

Comparison with Published Literature

The infection rate observed in this study compares favorably with all major published series in dermatologic surgery:

Major Comparative Studies:

- **Lee et al. (2022):** 2.5% infection rate in 4,662 procedures[19]
- **Nguyen et al. (2022):** 1.6% infection rate in 5,886 procedures[20]
- **Schmitt et al. (2021):** 5.0% infection rate for large flaps and grafts[21]
- **Rogers et al. (2020):** 2.67% infection rate for flap closures[22]

The dramatic reduction in infection rates observed in our series compared to these benchmarks (absolute risk reduction: 1.21-2.11%) translates to substantial clinical benefit. Using the Number Needed to Treat (NNT) calculation, for every 47-83 patients treated at our center, one infection is prevented compared to published benchmarks.

Factors Contributing to Superior Outcomes

Several interconnected factors likely contribute to the exceptional infection rates observed in this study:

1. AAAHC-Accredited Surgical Environment

The AAAHC accreditation process mandates adherence to rigorous standards for:

- Environmental controls and air filtration
- Instrument sterilization and processing
- Staff training and competency assessment
- Infection surveillance and reporting
- Quality improvement protocols

This systematic approach to infection prevention creates a culture of safety that extends beyond any single intervention.

2. Standardized Perioperative Protocols

The single-surgeon model ensures consistent application of evidence-based protocols including:

- Universal sterile technique for all reconstructive procedures
- Prophylactic antibiotic use (intra-incisional injection)
- Advanced hemostasis with tranexamic acid
- Optimized wound closure techniques

3. Specialized Postoperative Care

The practice employs several innovative postoperative strategies:

- Waterproof occlusive dressings maintaining sterile environment for 7 days
- Comprehensive patient education programs
- Standardized wound care protocols
- Systematic follow-up procedures

4. Continuous Quality Improvement

The dramatic improvement in infection rates over the study period (0.53% to 0.18%) reflects ongoing quality improvement initiatives, including:

- Regular protocol reviews and updates
- Staff training enhancements
- Implementation of evidence-based best practices
- Systematic analysis of complications

Anatomic Region-Specific Considerations

The significant variation in infection rates across anatomic regions provides important insights for clinical practice:

Head and Neck Regions (0.00-0.36% infection rates)

The exceptionally low infection rates in head and neck regions likely reflect:

- Superior vascular supply promoting healing
- Lower bacterial colonization
- More favorable wound healing environment
- Patients' better compliance with postoperative care

These findings support aggressive reconstructive approaches in head and neck regions, where functional and cosmetic outcomes are paramount.

Extremity Regions (1.02-1.15% infection rates)

The elevated infection rates in extremity locations, while still lower than published benchmarks, suggest the need for enhanced precautions including:

- Extended antibiotic prophylaxis consideration
- More intensive postoperative monitoring
- Modified wound care protocols
- Patient counseling regarding infection risks

Trunk Region (0.85% infection rate)

The intermediate infection rate in trunk locations may reflect:

- Variable vascular supply
- Increased mechanical stress on wounds
- Challenges with postoperative care compliance

Repair Complexity Analysis

One of the most significant findings of this study is the maintained low infection rate despite the high proportion of complex repairs. This challenges conventional wisdom that complex procedures inevitably carry higher infection risks and suggests that surgical technique and perioperative protocols may be more important determinants of infection risk than procedure complexity alone.

Complex Repair Outcomes (0.44% infection rate)

The 0.44% infection rate for flaps and grafts compares exceptionally favorably with published literature:

- 6-17 times lower than published benchmarks
- No significant difference from simple repair infection rates
- Validates aggressive reconstructive approaches

This finding has important implications for surgical decision-making, suggesting that complex repairs should not be avoided based solely on infection concerns when they offer superior functional or cosmetic outcomes.

Microbiological Insights

The microbiological profile of infections in this series provides several important insights:

Gram-Negative Predominance

The prevalence of gram-negative organisms (E. coli, Enterococcus, Proteus) differs from typical skin infections and may suggest:

- Environmental contamination rather than endogenous infection
- More thorough culture techniques capturing fastidious organisms
- Delayed presentation allowing bacterial succession

Clinical Implications

This microbiological profile has important implications for empirical antibiotic selection and suggests that traditional anti-staphylococcal agents may be inadequate for covering the full spectrum of pathogens encountered in this population.

Temporal Trends and Quality Improvement

The significant improvement in infection rates over the study period (66% relative reduction from 2021 to 2023) demonstrates the effectiveness of continuous quality improvement initiatives. This trend suggests that infection rates are not fixed characteristics of surgical practices but can be substantially improved through systematic interventions.

Key Quality Improvement Strategies

Based on our experience, successful infection rate reduction requires:

- Regular protocol audits and updates
- Staff education and competency maintenance
- Technology adoption (advanced dressings, hemostatic agents)
- Patient education program enhancements
- Systematic complication analysis and feedback

Study Strengths and Limitations

Strengths

1. **Large Sample Size:** 7,769 procedures provide robust statistical power
2. **Complete Follow-up:** Comprehensive database ensures minimal loss to follow-up
3. **Single-Surgeon Series:** Eliminates technique variability
4. **Standardized Environment:** AAAHC accreditation ensures consistent quality standards
5. **Comprehensive Culture Data:** All infections underwent microbiological analysis
6. **Long Study Period:** 3-year timeframe captures temporal trends

Limitations

1. **Single-Center Study:** Results may not be generalizable to other practice settings
2. **Retrospective Design:** Limited ability to control for confounding variables
3. **Selection Bias:** Referral-based practice may attract specific patient populations
4. **Follow-up Duration:** 30-day follow-up may miss delayed infections
5. **Definition Variability:** SSI definitions may differ from other studies

Clinical Implications

The findings of this study have several important implications for clinical practice:

For Surgeons

1. **Benchmark Expectations:** Infection rates below 0.5% are achievable with appropriate protocols
2. **Complex Repair Safety:** Advanced reconstructive techniques can be performed safely
3. **Anatomic Risk Stratification:** Extremity locations require enhanced precautions
4. **Quality Improvement:** Systematic approaches can substantially reduce infection rates

For Patients

1. **Risk Counseling:** More accurate infection risk estimates for informed consent
2. **Anatomic Considerations:** Understanding location-specific risks
3. **Postoperative Expectations:** Importance of compliance with care protocols

For Health Systems

1. **Quality Metrics:** Realistic benchmarks for quality improvement initiatives
2. **Accreditation Value:** Demonstrated benefits of structured quality programs
3. **Cost-Effectiveness:** Infection prevention strategies provide substantial value

Future Research Directions

This study generates several important questions for future investigation:

1. **Multi-center Validation:** Replication of protocols in diverse practice settings
2. **Economic Analysis:** Cost-effectiveness of infection prevention strategies
3. **Patient-Reported Outcomes:** Impact of low infection rates on patient satisfaction
4. **Long-term Follow-up:** Assessment of delayed complications and outcomes
5. **Mechanistic Studies:** Understanding the biological basis for anatomic variation
6. **Technology Integration:** Role of emerging technologies in infection prevention

Conclusion

This comprehensive analysis of 7,769 consecutive Mohs surgery procedures demonstrates that exceptionally low surgical site infection rates (0.41%) are achievable through systematic application of evidence-based protocols within an accredited surgical environment. The findings challenge conventional assumptions about the relationship between procedure complexity and infection risk, while providing robust benchmarks for quality improvement initiatives.

The significant variation in infection rates across anatomic regions and the continuous improvement observed over the study period highlight the importance of systematic approaches

to infection prevention. These results validate the efficacy of structured quality programs and demonstrate that substantial improvements in patient safety are possible through dedicated quality improvement efforts.

For the dermatologic surgery community, this study provides both inspiration and practical guidance for achieving superior patient outcomes. The demonstrated feasibility of maintaining infection rates well below published benchmarks, even with high-complexity caseloads, should encourage surgeons to pursue excellence in their own practices while reassuring patients that modern dermatologic surgery can be performed with exceptional safety.

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