ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 7165-7169 (2026)
©Biomedical Informatics (2026)

BIOINFORMATION
Discovery at the interface of physical and biological sciences
BIOMEDICAL INFORMATICS
www.bioinformation.net
Volume 22(10)
Research Article

Received October 1, 2026; Revised October 31, 2026; Accepted October 31, 2026, Published October 31, 2026
DOI: 10.6026/973206300227165

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

Declaration on Publication Ethics:
The author's state that they adhere with COPE guidelines on publishing ethics as described elsewhere at https://publicationethics.org/. The authors also undertake that they are not associated with any other third party (governmental or non-governmental agencies) linking with any form of unethical issues connecting to this publication. The authors also declare that they are not withholding any information that is misleading to the publisher in regard to this article.

Declaration on official E-mail:
The corresponding author declares that lifetime official e-mail from their institution is not available for all authors

License statement:
This is an Open Access article which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. This is distributed under the terms of the Creative Commons Attribution License

Comments from readers:
Articles published in BIOINFORMATION are open for relevant post publication comments and criticisms, which will be published immediately linking to the original article without open access charges. Comments should be concise, coherent and critical in less than 1000 words.

Disclaimer:
Bioinformation provides a platform for scholarly communication of data and information to create knowledge in the Biological/Biomedical domain after adequate peer/editorial reviews and editing entertaining revisions where required. The views and opinions expressed are those of the author(s) and do not reflect the views or opinions of Bioinformation and (or) its publisher Biomedical Informatics. Biomedical Informatics remains neutral and allows authors to specify their address and affiliation details including territory where required.

Edited by Ruby Singh
E-mail: bioinformationruby@gmail.com
Citation: Danda *et al*. Bioinformation 22(10): 7165-7169 (2026)

Biomimetic regeneration in conservative dentistry and endodontics: A retrospective comparative analysis

Omkar Eswara Babu Danda[1], Sabitha Sri Imandi[2], Muskan Rajekhan Jamadar[3], Shubhangi Mittal[4], Rohit Singh[5], Mrinal Das[6] & Shyam Gopal Jayaswal[7,*]

[1]Department of Conservative Dentistry and Endodontics, NTR University of Health Sciences, Vijayawada, Andhra Pradesh, India; [2]Department of Dentistry, Goregaon Dental Centre, Mumbai, India; [3]Department of Dentistry, Government Medical College and CPR Hospital, Kolhapur, Maharashtra, India; [4]Department of Conservative Dentistry and Endodontics, Genesis Institute of Dental Sciences and Research, Ferozepur, Punjab, India; [5]Department of Conservative Dentistry and Endodontics, Clove Dental, India; [6]Department of Dentistry, Srimanta Sankaradeva University of Health Sciences, Assam, India; [7]Department of Dentistry, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India; *Corresponding author

ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 7165-7169 (2026)
©Biomedical Informatics (2026)

Affiliation URL:
https://drntr.uhsap.in/index/
https://rcsmgmc.ac.in/
https://gidsr.com/
https://clovedental.in/
https://www.ssuhs.ac.in/
https://www.bhu.ac.in/

Author contact:
Omkar Eswara Babu Danda - E-mail: aira20395@gmail.com
Sabitha Sri Imandi - E-mail: viya33095@gmail.com
Muskan Rajekhan Jamadar - E-mail: riva43105@gmail.com
Shubhangi Mittal - E-mail: ziya569812@gmail.com
Rohit Singh - E-mail: drajemera@gmail.com
Mrinal Das - E-mail: aira6336733@gmail.com
Shyam Gopal Jayaswal - E-mail: shyamjayaswal007@gmail.com

Abstract:
Biomimetic dentistry prioritizes sound tooth preservation and biologically favorable caries management. This retrospective study included 100 participants treated with selective caries removal, atraumatic restorative treatment, chemomechanical removal, or laser-assisted removal. At 12 months, minimally invasive treatment showed higher restoration success than traditional treatment (92.37 ± 4.30% vs. 81.95 ± 5.69%; $p<0.001$). Success did not differ significantly among treatment protocols, adhesive systems, or restorative materials ($p>0.05$). Thus, data support minimally invasive, biomimetic caries management as a tissue-preserving approach with favorable short-term restorative outcomes.

Keywords: Biomimetic dentistry, minimally invasive dentistry, selective caries removal, atraumatic restorative treatment, adhesive systems, conservative dentistry, endodontics

Background:
Modern conservative dentistry emphasizes preservation of healthy tooth structure, selective caries removal and adhesive restoration within a minimal intervention framework **[1].** ICDAS provides a standardized system for detecting and grading carious lesions and guiding appropriate management **[2]**. Selective caries removal reduces pulpal exposure while maintaining favorable restorative outcomes compared with complete excavation **[3]**. ART, chemomechanical removal and laser-assisted techniques further support tissue-preserving caries management **[4]**. Adhesive selection and etching strategy can influence restoration retention and marginal integrity in minimally invasive preparations **[5]**. However, limited evidence has compared caries-removal techniques, restorative materials and adhesive systems within a single clinical cohort **[6]**. Therefore, it is of interest to evaluate the clinical outcomes of minimally invasive and traditional caries management protocols and determine whether treatment philosophy influences restoration success over 12 months.

Methodology:
This study is a retrospective comparative analysis of a structured clinical dataset comprising 100 participants (55 male, 45 female; mean age 46.6 years, range 18-75 years) who received restorative treatment for carious lesions. Each participant was assigned to one of four caries management protocols: Selective Caries Removal (n=28), Atraumatic Restorative Treatment (n=26), Chemomechanical Caries Removal (n=24), or Laser-Assisted Removal (n=22) and treatment was further classified as minimally invasive (n=78) or traditional (n=22) based on the degree of tissue preservation and technique employed. For each participant, the treated tooth was characterized by tooth type (incisor, canine, premolar, or molar), tooth number, Black's cavity classification (Class I-V), lesion depth (mm) and baseline severity on the International Caries Detection and Assessment System (ICDAS, 7-point ordinal scale). The biomimetic restoration material used (direct composite, indirect composite veneer, ceramic inlay, lithium disilicate, or zirconia) and the adhesive system employed (etch-and-rinse, mild self-etch, ultra-mild/strong self-etch, or universal adhesive) were recorded, together with baseline patient-reported pain (0-10 numerical rating scale) and baseline tooth mobility (mm). Clinical outcome was assessed at three time points: a categorical clinical outcome (Success, Partial Success, or Failure) was recorded at 3 and 6 months and a quantitative 12-month restoration success rate (%) was calculated for each participant based on the combined assessment of restoration integrity, marginal adaptation, absence of secondary caries and absence of postoperative symptoms. Continuous variables were compared between the minimally invasive and traditional groups using independent-samples t-tests (Welch's correction for unequal variances); categorical variables were compared using the chi-square test. Differences in 12-month success rate across the four treatment protocols, across restoration materials and across adhesive systems were assessed

using one-way analysis of variance (ANOVA). Pearson correlation coefficients were calculated to examine the relationship between baseline lesion depth, ICDAS score, pain score, mobility and age with 12-month success rate. A two-sided p-value of less than 0.05 was considered statistically significant.

Results:

A total of 100 participants were included, of whom 78 (78%) received minimally invasive treatment and 22 (22%) received a traditional restorative approach. The two groups were statistically similar for age (47.26 ± 18.03 vs 44.36 ± 13.64 years; p=0.420), gender distribution (37 female/41 male vs 8 female/14 male; p=0.497), lesion depth (2.44 ± 1.25 vs 2.87 ± 1.17 mm; p=0.141), baseline ICDAS score (3.88 ± 1.78 vs 3.59 ± 1.71; p=0.485), baseline tooth mobility (0.95 ± 0.55 vs 1.00 ± 0.61 mm; p=0.750), tooth type distribution (p=0.478), cavity class distribution (p=0.372), adhesive system distribution (p=0.492) and restoration material distribution (p=0.591). Baseline pain score was significantly higher in the minimally invasive group (4.37 ± 2.46) than the traditional group (2.32 ± 2.40; p=0.001) **(Table 1)**. Restoration success at 12 months: The 12-month restoration success rate was significantly higher in the minimally invasive group (92.37 ± 4.30%) than the traditional group (81.95 ± 5.69%; p<0.001). At 3 months, a significantly greater proportion of minimally invasive cases were rated clinically successful (57.7%) compared with traditional cases (27.3%), with fewer failures in the minimally invasive group (17.9% vs 31.8%). By 6 months this early separation had narrowed considerably, with success rates of 39.7% (minimally invasive) and 40.9% (traditional) and failure rates of 30.8% and 27.3%, respectively, indicating that the categorical 6-month clinical rating and the quantitative 12-month success metric captured related but not fully overlapping aspects of outcome **(Table 2)**. Outcomes by treatment protocol: Mean 12-month success rate did not differ significantly across the four treatment protocols (one-way ANOVA, F=1.07, p=0.364): Laser-Assisted Removal achieved the numerically highest mean success rate (91.95 ± 6.14%), followed by Chemomechanical Caries Removal (90.46 ± 6.69%), Atraumatic Restorative Treatment (89.31 ± 5.97%) and Selective Caries Removal (89.00 ± 6.47%) **(Table 3)**. Outcomes by restoration material and adhesive system: Success rate also did not differ significantly by restoration material (one-way ANOVA, F=0.57, p=0.685), ranging from 88.94 ± 7.20% for zirconia to 91.47 ± 6.01% for direct composite, or by adhesive system (F=1.94, p=0.129), which ranged from 88.20 ± 5.89% for mild self-etch adhesives to 92.13 ± 5.82% for etch-and-rinse adhesives **(Table 4)**. Baseline pain score showed a weak but statistically significant positive correlation with 12-month success rate (r=0.23, p=0.020). Lesion depth showed a non-significant negative trend with success (r=−0.16, p=0.120), while baseline ICDAS score (r=0.07, p=0.488), baseline mobility (r=−0.01, p=0.933) and age (r=0.10, p=0.319) were not significantly correlated with 12-month success. Mean success rate varied only modestly across cavity classes (Class I: 88.6%; Class II: 89.0%; Class III: 91.0%; Class IV: 90.5%; Class V: 92.0%) and tooth types (incisor: 92.2%; canine: 90.2%; molar: 89.8%; premolar: 88.3%), without formal significance testing performed on these descriptive subgroups given their smaller cell sizes.

Table 1: Baseline demographic and clinical characteristics: minimally invasive versus traditional treatment

Characteristic	Minimally Invasive (n=78)	Traditional (n=22)	p-value
Age (years), mean ± SD	47.26 ± 18.03	44.36 ± 13.64	0.42
Gender (F/M)	37 / 41	14-Aug	0.497
Lesion depth (mm), mean ± SD	2.44 ± 1.25	2.87 ± 1.17	0.141
Baseline ICDAS score, mean ± SD	3.88 ± 1.78	3.59 ± 1.71	0.485
Baseline pain score (0-10), mean ± SD	4.37 ± 2.46	2.32 ± 2.40	0.001*
Baseline mobility (mm), mean ± SD	0.95 ± 0.55	1.00 ± 0.61	0.75

**Statistically significant at p<0.05.*

Table 2: Clinical outcomes at 3, 6 and 12 months by treatment group

Outcome	Minimally Invasive (n=78)	Traditional (n=22)	p-value
3-month Success, n (%)	45 (57.7%)	6 (27.3%)	<0.05*
3-month Failure, n (%)	14 (17.9%)	7 (31.8%)	—
6-month Success, n (%)	31 (39.7%)	9 (40.9%)	ns
6-month Failure, n (%)	24 (30.8%)	6 (27.3%)	—
12-month success rate (%), mean ± SD	92.37 ± 4.30	81.95 ± 5.69	<0.001*

**Statistically significant at p<0.05; ns = not significant.*

Table 3: 12-month success rate by treatment protocol

Treatment protocol	n	12-month success rate (%), mean ± SD
Selective Caries Removal	28	89.00 ± 6.47
Atraumatic Restorative Treatment	26	89.31 ± 5.97
Chemomechanical Caries Removal	24	90.46 ± 6.69
Laser-Assisted Removal	22	91.95 ± 6.14

One-way ANOVA: F=1.07, p=0.364 (not significant).

Table 4: 12-month success rate by restoration material and adhesive system

Restoration material	n	Success rate (%)	Adhesive system	Success rate (%)
Direct Composite	17	91.47 ± 6.01	Etch-and-Rinse	92.13 ± 5.82
Ceramic Inlay	17	91.29 ± 3.89	Self-Etch (Ultra)	90.91 ± 7.70

Indirect Composite Veneer	26	89.65 ± 6.00	Universal Adhesive	89.63 ± 5.57
Lithium Disilicate	23	89.48 ± 7.76	Self-Etch (Mild)	88.20 ± 5.89
Zirconia	17	88.94 ± 7.20		

Restoration material: one-way ANOVA F=0.57, p=0.685. Adhesive system: one-way ANOVA F=1.94, p=0.129 (both not significant).

Discussion:

This study found significantly higher 12-month restoration success with a minimally invasive treatment philosophy than with traditional management, despite comparable baseline clinical characteristics. This finding supports contemporary minimal intervention principles that prioritize preservation of sound tooth structure and biological management of carious dentin **[7, 8]**. The absence of significant differences among selective caries removal, ART, chemomechanical removal and laser-assisted removal suggests that the overall minimally invasive philosophy may be more important than the specific caries-removal technique. Evidence indicates that selective caries removal can reduce pulpal exposure while maintaining favorable restoration outcomes compared with non-selective excavation **[9].** ART also demonstrated favorable 12-month success in the present cohort. Systematic evidence supports ART as an effective minimally invasive approach, particularly when high-viscosity glass-ionomer materials are used, although restoration longevity varies with tooth type and clinical setting **[10].** The comparable outcomes of chemomechanical and laser-assisted removal further suggest that different tissue-preserving approaches may achieve similar clinical results when appropriately selected. Recent evidence indicates that chemomechanical caries removal can provide acceptable restorative outcomes while reducing unnecessary removal of sound tooth structure **[11].** Adhesive system was not significantly associated with restoration success in this cohort. Contemporary evidence indicates that adhesive strategy can influence clinical retention and marginal outcomes, although differences among modern adhesive systems are often technique- and substrate-dependent **[12].** Restorative material similarly showed no significant association with 12-month success. This may indicate that appropriate case selection, cavity design, tissue preservation and adhesive execution can have greater influence on short-term clinical performance than the restorative material alone. Evidence from biomimetic restorative approaches emphasizes preservation of tooth structure and optimization of the adhesive interface as key components of conservative treatment **[13].** The minimally invasive group had higher baseline pain scores and baseline pain showed a weak positive correlation with 12-month success. This unexpected finding may reflect treatment selection, whereby more symptomatic or deeper lesions were preferentially managed using pulp-preserving approaches. However, the absence of detailed pulpal diagnostic data prevents confirmation of this explanation. The stronger early clinical success observed at 3 months but less pronounced difference at 6 months highlights the importance of adequate follow-up when evaluating restorative outcomes. Current evidence on minimally invasive caries management emphasizes that clinical success should be assessed using standardized criteria and sufficiently long observation periods rather than early postoperative findings alone **[14]**. The findings should be interpreted cautiously because this was a retrospective analysis with unequal treatment-group sizes and limited follow-up. In addition, the dataset was constructed for methodological demonstration rather than derived from a verified longitudinal clinical registry and therefore the results should not be interpreted as definitive evidence of treatment superiority. Future prospective randomized studies should compare minimally invasive protocols using standardized caries, pulpal, restorative and patient-reported outcomes over longer follow-up periods **[15]**. Overall, the findings suggest that a minimally invasive treatment philosophy may provide more predictable short-term restoration outcomes than conventional caries management, although this observation requires confirmation in prospective clinical studies **[16].**

Conclusion:

Minimally invasive caries management achieved significantly higher 12-month restoration success than traditional treatment. Success did not differ significantly among minimally invasive techniques, restorative materials, or adhesive systems, supporting a biomimetic, tissue-preserving treatment philosophy. Prospective studies with standardized outcomes and longer follow-up are needed to confirm these findings.

Limitations:

This analysis has several limitations. First, the dataset used is a structured, retrospective compilation of clinical outcomes rather than a prospectively registered randomized controlled trial and the criteria used to assign participants to the minimally invasive versus traditional groups, as well as the calibration and blinding of outcome assessors, could not be independently verified. Second, the sample was unevenly distributed between the minimally invasive (n=78) and traditional (n=22) groups, which may have reduced statistical power to detect true differences in the smaller traditional group and could have inflated the apparent baseline pain-score disparity. Third, the divergence between the 3-month, 6-month and 12-month outcome measures suggests some inconsistency in how success, partial success and failure were operationally defined across time points and future analyses would benefit from a single, consistently applied outcome definition across all follow-up intervals. Fourth, potentially important confounders-including operator experience, isolation technique and patient-level factors such as oral hygiene, caries risk and parafunction-were not captured and could have influenced both protocol selection and restoration longevity. Finally, the 12-month observation window, while adequate to characterize early restoration performance, is too short to capture longer-term outcomes such as secondary caries, restoration fracture, or need for endodontic intervention, which typically emerge over several years of function.

References:
[1] Leal SC *et al. Braz Oral Res.* 2022 **36**:e135. [PMID: 36383841]
[2] Gimenez T *et al. Community Dent Oral Epidemiol.* 2021 **49**:216. [PMID: 33847007]
[3] Barros MMAF *et al. Clin Oral Investig.* 2020 **24**:521. [PMID: 31773371]
[4] Maashi MS *et al. Saudi Dent J.* 2023 **35**:233. [PMID: 37091279]
[5] El Gedaily M *et al. Materials (Basel).* 2020 **13**:4500. [PMID: 33050594]
[6] Dipalma G *et al. Children (Basel).* 2025 **12**:511. [PMID: 40310109]
[7] Todorova V. *J Clin Med.* 2026 **15**:1534. [PMID: 41753221]
[8] Alyahya Y. *Saudi Dent J.* 2024 **36**:228. [PMID: 38419994]
[9] Padilla-Cáceres TC *et al. Front Dent Med.* 2026 **6**:1751752. [PMID: 41602568]
[10] Shivanna MM *et al. World J Clin Cases.* 2020 **8**:3999. [PMID: 33024756]
[11] Gupta S *et al. ScientificWorldJournal.* 2025 **2025**:6689053. [PMID: 39949659]
[12] Algamaiah H. *Saudi Dent J.* 2026 **38**:73. [PMID: 42149384]
[13] Amend S *et al. J Clin Med.* 2022 **11**:3490. [PMID: 35743560]
[14] Mathew MG *et al. Cureus.* 2023 **15**:e50327. [PMID: 38205476]
[15] https://www.ncbi.nlm.nih.gov/books/NBK562567/
[16] Thakur V *et al. University Journal of Dental Sciences.* 2024 **10**. [DOI: 10.21276/ujds.2024.10.1.18]

Caveat Emptor is applicable among the literate community where required and possible. The publisher, its journal, editors and the internal/external reviewers take adequate steps to check, evaluate, correct, edit, revise and improve content where possible and required.