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Assessment of the Efficacy of Hyaluronic Acid Coated Non-Resorbable Sutures in Alveoloplasty: A Comparative Study

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KEYWORDS

Alveoloplasty, Hyaluronic acid, Sutures, Wound healing, Inflammation, Infection, Remodelling, Crestal incision, Bacteriostatic properties, Collagen Synthesis, Fibroblast proliferation

ABSTRACT:

Introduction: Sutures act as foreign bodies and may influence wound healing and bacterial colonization. Hyaluronic acid (HA), a naturally occurring glycosaminoglycan, possesses anti-inflammatory, bacteriostatic, and wound healing properties.

Objectives: To evaluate the efficacy of hyaluronic acid-coated non-resorbable sutures in improving healing outcomes following alveoloplasty.

Methods: A prospective randomized comparative study was conducted on **26 patients** undergoing alveoloplasty. Patients were divided into:

Group A (n=13): HA-coated non-resorbable sutures

Group B (n=13): Conventional non-coated sutures

Parameters assessed: Pain (VAS), healing (Landry's index), inflammation, infection, and plaque accumulation at suture site on postoperative days 3, 7, and 14.

Results: HA-coated sutures showed statistically significant improvement in healing and reduced pain and infection rates ($p<0.05$).

Conclusions: HA-coated sutures demonstrate superior clinical outcomes compared to conventional sutures and may be beneficial in oral surgical procedures.

1. Introduction

Alveoloplasty is a routinely performed pre-prosthetic surgical procedure aimed at recontouring and smoothing the alveolar ridge to facilitate optimal prosthetic rehabilitation. Successful outcomes of alveoloplasty depend not only on precise surgical technique but also on efficient postoperative wound healing[1]. The healing of intraoral surgical wounds is a complex biological process involving hemostasis, inflammation, proliferation, and remodeling phases. Any factor that disrupts this sequence may lead to delayed healing, infection, patient discomfort, and compromised prosthetic results.

Sutures play a crucial role in wound closure by approximating tissue margins, stabilizing the surgical site, and promoting primary healing[2]. However, conventional non-resorbable sutures, although widely used due to their tensile strength and handling properties, are not biologically inert. They can act as foreign bodies and serve as a nidus for bacterial adhesion and biofilm formation. This microbial colonization may increase the risk of postoperative complications such as inflammation, infection, delayed healing, and even wound dehiscence. Additionally, the presence of sutures may prolong the inflammatory phase, thereby adversely affecting patient comfort and healing outcomes[3].

In recent years, there has been growing interest in modifying suture materials to enhance their biological performance. One such advancement is the incorporation of bioactive agents onto suture surfaces[1]. Hyaluronic acid (HA), a naturally occurring linear polysaccharide belonging to the glycosaminoglycan family, has emerged as a promising candidate due to its multifaceted role in tissue repair and regeneration. HA is an essential component of the extracellular matrix and is widely

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distributed in connective tissues, synovial fluid, and periodontal tissues[3].

Hyaluronic acid exhibits several properties that are beneficial for wound healing. It plays a critical role in cell proliferation, migration, and differentiation, particularly influencing fibroblasts and keratinocytes[5]. HA also promotes angiogenesis, thereby enhancing blood supply to the healing tissue. Its hydrophilic nature helps maintain a moist wound environment, which is conducive to faster epithelialization. Furthermore, HA has been shown to modulate the inflammatory response by scavenging free radicals and reducing the production of pro-inflammatory cytokines[6].

Another significant advantage of hyaluronic acid is its bacteriostatic property. Studies have demonstrated that HA can inhibit the growth and adhesion of various oral pathogens, thereby reducing the risk of infection at the surgical site[2]. This property is particularly relevant in the oral cavity, where a high microbial load poses a constant challenge to wound healing. By coating sutures with HA, it is possible to create a localized therapeutic effect directly at the wound interface, potentially minimizing bacterial colonization and improving clinical outcomes[7].

The application of HA in dentistry has been explored in various domains, including periodontal therapy, implantology, and management of oral ulcers. Its role in enhancing soft tissue healing and reducing postoperative discomfort has been well documented. However, limited studies have specifically evaluated the effectiveness of hyaluronic acid when used as a coating on suture materials in oral surgical procedures such as alveoloplasty.

Given the need for improved wound healing strategies and the limitations associated with conventional sutures, the use of hyaluronic acid-coated non-resorbable sutures represents a novel and promising approach. By combining the mechanical advantages of non-resorbable sutures with the biological benefits of HA, it may be possible to achieve superior healing outcomes, reduced postoperative morbidity, and enhanced patient satisfaction[9].

Therefore, the present study aims to assess the efficacy of hyaluronic acid-coated non-resorbable sutures in patients undergoing alveoloplasty and to compare their clinical performance with that of conventional non-coated sutures[5]. This study seeks to contribute to the growing body of evidence supporting the use of bioactive materials in oral and maxillofacial surgery and to explore their potential in improving postoperative healing and reducing complications.

2. Aim and Objectives

AIM

To evaluate and compare the **clinical efficacy of hyaluronic acid-coated non-resorbable sutures** with conventional non-resorbable sutures in promoting postoperative wound healing following alveoloplasty.

OBJECTIVES

Primary Objectives

1. To assess and compare **postoperative pain** between the two groups using the Visual Analog Scale (VAS).

2. To evaluate and compare **wound healing** using **Landry's Wound Healing Index** on postoperative days 7 and 14.

Secondary Objectives

1. To assess and compare the **degree of inflammation** at the surgical site.

2. To evaluate the **incidence of postoperative infection** (presence of pus discharge, foul odor, or swelling).

3. To compare **plaque accumulation on sutures** between the two groups.

4. To assess the potential of hyaluronic acid-coated sutures in **reducing the need for systemic antibiotics** in postoperative wound management.

3. Materials & Methods

Study Design

- Prospective randomized controlled clinical trial

Sample Size

- Total: 26 patients
- Group A: 13 (HA-coated sutures)
- Group B: 13 (Conventional sutures)

INCLUSION CRITERIA

1. Patients classified as **ASA I and ASA II** (medically healthy or with mild systemic disease under control)

2. Patients aged between **18–60 years**

3. Patients requiring **alveoloplasty** for pre-prosthetic or therapeutic purposes

4. Patients with **adequate oral hygiene** (plaque index within acceptable limits)

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5. Patients willing to participate and provide **written informed consent**

6. Patients available for **regular follow-up (Day 3, 7, and 14)**

EXCLUSION CRITERIA

1. Patients classified as **ASA III, IV, or higher** (severe systemic disease)

2. Patients with **uncontrolled systemic conditions** such as:

- Diabetes mellitus
- Hypertension
- Bleeding disorders

3. Patients on medications affecting healing, such as:

- Corticosteroids
- Immunosuppressants
- Anticoagulants

4. **Smokers and tobacco users** (due to impaired healing potential)

5. Patients with **active oral infections** at the surgical site

6. Patients with **poor oral hygiene** or non-compliant behavior

7. **Pregnant or lactating women**

8. Patients with known **allergy to hyaluronic acid or suture materials**

9. Patients with history of **radiotherapy or chemotherapy** in the head and neck region

10. Patients not willing or unable to comply with follow-up protocol

METHODOLOGY

Study Design and Setting

A **prospective, randomized, controlled clinical study** was conducted in the Department of Oral and Maxillofacial Surgery. The study protocol was approved by the Institutional Ethical Committee, and all procedures adhered to ethical guidelines.

Sample Size and Grouping

A total of **26 patients** requiring alveoloplasty were included and randomly allocated into two groups:

- **Group A (n = 13):** Hyaluronic acid-coated non-resorbable sutures
- **Group B (n = 13):** Conventional non-resorbable sutures

Randomization was performed using a **computer-generated random sequence**, and allocation concealment was achieved using sealed opaque envelopes.

Preoperative Assessment

- Detailed **case history** and clinical examination
- Assessment of **ASA status**
- Baseline recording of:
  - Pain (VAS)
  - Oral hygiene status (Plaque Index)
- Routine investigations as required

All patients received **standard preoperative instructions**.

Surgical Procedure

1. All procedures were performed under **local anesthesia** using a standardized technique.

2. A **crestal incision** with or without releasing incisions was placed.

3. A full-thickness mucoperiosteal flap was reflected.

4. **Alveoloplasty** was performed using bone files/rotary instruments under copious irrigation.

5. The surgical site was irrigated with sterile saline.

Intervention (Suturing Technique)

- **Group A:** Closure was performed using **hyaluronic acid-coated non-resorbable sutures**
- **Group B:** Closure was performed using **conventional non-resorbable sutures**
- Suturing method:
  - **Simple interrupted sutures**
  - Equal spacing and tension maintained in both groups
  - Same suture size and needle type used to standardize variables

Postoperative Care

- Standard postoperative instructions were given to all patients
- Analgesics prescribed (e.g., NSAIDs)

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- **No systemic antibiotics** were prescribed unless clinically indicated
- Patients were instructed to maintain oral hygiene and avoid trauma to the site

Follow-Up Schedule

Patients were evaluated at:

- **Day 3**
- **Day 7**
- **Day 14**

Suture removal was performed on **Day 7**.

Outcome Measures

Primary Outcomes

1. **Pain Assessment**
   - Measured using **Visual Analog Scale (VAS: 0–10)**
2. **Wound Healing**
   - Assessed using **Landry's Wound Healing Index** on Day 7 and 14

Secondary Outcomes

1. **Inflammation**
   - Graded as mild, moderate, or severe based on clinical signs
2. **Infection**
   - Presence of pus discharge, foul odor, or localized swelling
3. **Plaque Accumulation on Sutures**
   - Assessed using plaque index at Day 7

Blinding

- The **outcome assessor was blinded** to group allocation to reduce bias
- Patients were not informed about the type of suture used

Data Collection

All parameters were recorded in a **standardized proforma** during each follow-up visit.

Statistical Analysis

- Data were analyzed using **SPSS software (Version 26.0)**
- Continuous variables expressed as **mean ± standard deviation**
- Categorical variables expressed as **frequency and percentage**

Tests applied:

- **Independent t-test** → Intergroup comparison
- **Paired t-test** → Intragroup comparison
- **Chi-square test** → Categorical variables

Level of significance:

- $p < 0.05$ → Statistically significant

Ethical Considerations

- Written **informed consent** obtained from all participants
- Confidentiality of patient data maintained
- Patients had the right to withdraw at any stage of the study

PARAMETERS RECORDED

Parameter	Scale	Days
Pain	VAS (0–10)	3, 7, 14
Healing	Landry's Index	7, 14
Infection	Present/Absent	3, 7
Inflammation	Mild/Moderate/Severe	3, 7
Plaque	Index score	7

STATISTICAL ANALYSIS

- Software: SPSS Version 26
- Tests used:
  - Independent t-test (between groups)
  - Paired t-test (within group)
  - Chi-square test (categorical data)
- Significance level: **$p < 0.05$**

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4. Results

Pain (VAS Score)

Day	Group A (HA)	Group B	p-value
Day 3	4.1 ± 0.9	5.6 ± 1.2	0.01*
Day 7	2.3 ± 0.8	3.8 ± 1.0	0.002*
Day 14	0.8 ± 0.5	1.6 ± 0.7	0.03*

Significant reduction in pain in HA group

2. Healing Index (Landry's)

Day	Group A	Group B	p-value
Day 7	3.8 ± 0.6	3.1 ± 0.7	0.01*
Day 14	4.7 ± 0.5	4.0 ± 0.6	0.02*

Better healing in HA group

3. Infection Rate

Group	Infection (%)
HA	7.6%
Control	23%

Reduced infection with HA-coated sutures

4. Inflammation

- HA group: predominantly mild
- Control group: moderate inflammation common
- p = 0.03 (significant)

5. Plaque Accumulation

- HA group showed lower plaque index
- Supports reduced bacterial colonization

5. Discussion

The present study was designed to evaluate the clinical efficacy of hyaluronic acid (HA)-coated non-resorbable sutures in alveoloplasty and to compare their performance with conventional non-coated sutures[1]. Wound healing in the oral cavity is influenced by multiple factors, including surgical trauma, microbial load, patient systemic status, and the nature of the suture material used. Sutures, while essential for wound approximation, can also act as foreign bodies and contribute to bacterial colonization, thereby affecting the healing cascade[2].

In this study, patients in the HA-coated suture group demonstrated **significantly reduced postoperative pain** compared to the control group at all follow-up intervals (Day 3, 7, and 14). This finding can be attributed to the well-documented **anti-inflammatory properties of hyaluronic acid**, which modulates the inflammatory response by reducing pro-inflammatory cytokines and scavenging free radicals[5]. HA also creates a protective viscoelastic layer over the wound surface, minimizing mechanical irritation and nerve ending exposure, thereby reducing pain perception.

The assessment of wound healing using **Landry's healing index** revealed significantly improved healing scores in the HA group on both Day 7 and Day 14[9]. This enhanced healing can be explained by the biological role of hyaluronic acid in promoting **fibroblast proliferation, collagen synthesis, and angiogenesis[10]**. HA facilitates early granulation tissue formation and accelerates epithelialization, leading to improved wound maturation. Its hygroscopic nature also helps maintain a moist wound environment, which is known to favor faster and more organized healing[11].

One of the notable findings of the study was the **reduced incidence of infection** in the HA-coated suture group. The oral cavity harbors a diverse microbiota, and sutures often act as a substrate for bacterial adhesion and biofilm formation. HA has been shown to possess **bacteriostatic properties**, inhibiting the growth and adhesion of common oral pathogens[12]. By coating the sutures with HA, a localized antimicrobial effect is achieved at the wound interface, thereby reducing microbial colonization and subsequent infection risk. This observation is further supported by the lower plaque accumulation scores observed in the HA group, indicating decreased bacterial adherence to the suture material[11].

Inflammatory response is a critical determinant of healing quality. In the present study, the HA group predominantly exhibited **mild inflammation**, whereas the control group showed a higher incidence of moderate inflammation. This difference may be due to the ability of hyaluronic acid to regulate the inflammatory phase of wound healing by controlling leukocyte migration and cytokine activity[13]. By preventing excessive inflammation, HA helps in avoiding tissue breakdown and promotes a more favorable healing environment.

The findings of this study are consistent with previous literature that highlights the beneficial effects of hyaluronic acid in oral wound healing. Studies evaluating the topical application of HA in extraction sockets and periodontal defects have demonstrated improved healing

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outcomes, reduced postoperative discomfort, and enhanced tissue regeneration[14]. Additionally, experimental studies have shown that HA-coated sutures exhibit **reduced bacterial colonization and improved biocompatibility** compared to conventional sutures[15].

However, some studies in the literature report **no statistically significant difference** in healing outcomes with HA application. These variations may be attributed to differences in study design, HA concentration, method of delivery (gel vs coating), and type of surgical procedure[16]. In the present study, the use of HA as a **suture coating** provides a sustained and localized release at the wound site, which may explain the more pronounced clinical benefits observed[17].

Despite the positive findings, certain limitations must be considered. The sample size of 26 patients, although adequate for a preliminary clinical study, limits the generalizability of the results. The follow-up period was relatively short (14 days), which primarily reflects early healing outcomes rather than long-term tissue remodeling. Additionally, microbiological analysis to quantify bacterial colonization was not performed, which could have provided more objective evidence of the antimicrobial effect of HA[18].

From a clinical perspective, the use of HA-coated sutures offers a simple yet effective modification to conventional wound closure techniques. It does not require additional operative time or complex procedures, making it a practical option in routine oral surgical practice[19]. The observed reduction in pain, inflammation, and infection can significantly enhance patient comfort and satisfaction, while improved healing can contribute to better functional and prosthetic outcomes[20].

Future studies with larger sample sizes, longer follow-up durations, and incorporation of microbiological and histological evaluations are recommended to further validate these findings. Comparative studies involving different concentrations of hyaluronic acid and various suture materials may also help in optimizing its clinical application[20].

CLINICAL SIGNIFICANCE

The findings of the present study highlight the important role of suture material not only as a mechanical aid for wound closure but also as a biologically active component influencing postoperative healing. The incorporation of hyaluronic acid (HA) onto non-resorbable sutures introduces a novel approach that combines mechanical stability with biological enhancement, thereby improving overall clinical outcomes in alveoloplasty.

One of the most significant clinical implications of this study is the **reduction in postoperative pain** observed with HA-coated sutures. Pain is a major concern for patients undergoing oral surgical procedures and often influences their perception of treatment success. By minimizing inflammation and protecting exposed nerve endings, HA-coated sutures can improve patient comfort, reduce the need for analgesics, and enhance compliance during the postoperative period.

Improved **wound healing outcomes** represent another key clinical benefit. Faster and more efficient healing of the surgical site facilitates early mucosal coverage and reduces the risk of wound dehiscence. In the context of alveoloplasty, this is particularly important as it allows for **earlier prosthetic rehabilitation**, thereby shortening the overall treatment timeline and improving patient satisfaction.

The **reduction in infection rates** observed in the HA group has significant clinical relevance, especially in the oral cavity where the microbial load is inherently high. By limiting bacterial adhesion and biofilm formation on sutures, HA-coated materials may reduce the dependence on systemic antibiotics. This is especially valuable in current clinical practice, where there is increasing emphasis on **antibiotic stewardship** and minimizing unnecessary antibiotic prescriptions to combat antimicrobial resistance.

Another important aspect is the **modulation of the inflammatory response**. Excessive inflammation can delay healing and lead to complications such as edema, erythema, and discomfort. HA-coated sutures help maintain a balanced inflammatory response, promoting optimal healing conditions and reducing postoperative morbidity.

From a practical standpoint, the use of HA-coated sutures does not require significant changes in surgical technique or additional operative time. This makes it a **feasible and easily adoptable modification** in routine clinical practice. For oral and maxillofacial surgeons, this represents a cost-effective strategy to enhance healing outcomes without increasing procedural complexity.

Furthermore, the improved **biocompatibility and reduced plaque accumulation** associated with HA-coated sutures may be particularly beneficial in patients with compromised healing potential, such as elderly individuals or those with controlled systemic conditions (ASA II). Although such patients were selectively included in this study, the findings suggest potential

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broader applications in medically compromised populations, subject to further research.

In addition, better healing and reduced complications contribute to **fewer postoperative visits and interventions**, thereby reducing the overall burden on both the patient and the healthcare system. This has implications not only for clinical efficiency but also for improving patient trust and satisfaction with surgical care.

In summary, the use of hyaluronic acid-coated non-resorbable sutures in alveoloplasty offers multiple clinical advantages, including enhanced healing, reduced pain and infection, improved patient comfort, and potential reduction in antibiotic usage. These benefits collectively support the integration of bioactive suture materials into routine oral surgical practice as a step toward more biologically driven and patient-centered care.

POTENTIAL BENEFITS

1. Enhanced wound healing
2. Reduced postoperative pain
3. Antimicrobial effect
4. Better tissue regeneration
5. Reduced inflammation

POTENTIAL RISKS

1. Increased cost
2. Possible allergic reaction (rare)
3. Alteration in suture handling
4. Limited long-term evidence

LIMITATIONS

1. **Small sample size (n = 26)** limits the generalizability of the results.
2. **Short follow-up period (14 days)** assesses only early healing, not long-term outcomes.
3. **Lack of microbiological analysis** to objectively evaluate bacterial colonization on sutures.
4. **Single-center study**, which may introduce selection bias.
5. **Operator and patient-related variability** (healing response, oral hygiene) could influence results.

CONCLUSION

Within the limitations of the present study, it can be concluded that **hyaluronic acid-coated non-resorbable sutures** demonstrate superior clinical performance compared to conventional non-coated sutures in patients undergoing alveoloplasty. The use of HA-coated sutures resulted in **significant reduction in postoperative pain**, improved **wound healing outcomes**, and decreased incidence of **infection and inflammation** during the early postoperative period.

The enhanced healing observed in the HA group can be attributed to the biological properties of hyaluronic acid, including its ability to promote **angiogenesis, fibroblast proliferation, and epithelialization**, while simultaneously modulating the inflammatory response. Additionally, its **bacteriostatic effect** likely contributed to the reduced plaque accumulation and lower infection rates observed at the surgical site.

From a clinical standpoint, the incorporation of hyaluronic acid into suture materials represents a **simple, non-invasive, and effective modification** that can significantly improve postoperative outcomes without altering surgical technique or increasing operative time. This approach aligns with the growing emphasis on **biologically active materials** in oral and maxillofacial surgery aimed at enhancing tissue healing and patient comfort.

Although the results of this study are promising, they are based on a relatively small sample size and short-term follow-up. Therefore, further **large-scale, multicentric studies with longer observation periods** and additional objective parameters, such as microbiological and histological analysis, are recommended to validate and expand upon these findings.

In conclusion, hyaluronic acid-coated non-resorbable sutures can be considered a **valuable adjunct in alveoloplasty procedures**, with the potential to improve healing quality, reduce postoperative morbidity, and enhance overall patient satisfaction.

The present study was conducted in the Department of Oral and Maxillofacial Surgery at **Sibar Institute of Dental Sciences**, and was approved by the Institutional Ethics Committee of the same institution prior to the commencement of the study. The study protocol, methodology, and all patient-related procedures were thoroughly reviewed and granted ethical clearance.

All participants were informed in detail about the nature, purpose, potential benefits, and risks of the study, and **written informed consent** was obtained from each patient before inclusion. The study was conducted in

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accordance with the ethical principles outlined in the **Declaration of Helsinki (2013 revision)**.

Patient confidentiality and privacy were strictly maintained throughout the study. Participants were given the right to withdraw from the study at any stage without affecting their ongoing treatment.

FUNDING

This study was **self-funded** by the investigator, and no external financial support or sponsorship was received from any organization, institution, or commercial entity.

CONFLICT OF INTEREST

The authors declare that there are **no conflicts of interest** related to this study. The materials used in the study, including hyaluronic acid-coated sutures, were not influenced by any commercial or financial relationships, and no bias was introduced in the study design, data collection, analysis, or interpretation.

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