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Review Article

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The Role of Superficial Skin Closure Technique on Postoperative Wound Healing Following Total Knee Arthroplasty: A Literature Review

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ABSTRACT
Total knee arthroplasty (TKA) is one of the most commonly performed orthopaedic procedures worldwide, offering substantial improvements in pain relief and mobility for patients with advanced knee osteoarthritis. Despite advancements in implant design and surgical technique, superficial wound complications remain a significant concern. These include delayed healing, wound dehiscence, infection, and excessive scar formation, potentially prolonging hospital stay, and reducing patient satisfaction. While deep tissue closure and joint mechanics have been extensively studied in orthopaedics, the influence of superficial skin closure techniques on wound outcomes has received less attention. The anterior knee incision traverses a high-tension, mobile area susceptible to healing complications and scar contracture. As such, the technique of skin closure may play a more critical role in postoperative recovery than traditionally recognized.

This review examines current literature evaluating the relationship between different superficial skin closure techniques—including subcuticular sutures, staples, and tissue adhesives—and their impact on wound healing outcomes, scar quality, and early postoperative function following TKA. Evidence suggests certain closure techniques, particularly continuous subcuticular sutures, may promote better wound approximation and tissue perfusion, reduce skin tension, and yield more favorable scar profiles compared to traditional interrupted sutures or staples. Some studies also report reduced rates of wound complications and improved patient-reported outcomes with subcuticular methods. However, the majority of research has focused on cosmetic or patient satisfaction outcomes, with fewer studies linking closure technique to orthopaedic recovery metrics, such as early range of motion, infection risk, or revision surgery. The superficial closure technique may have meaningful implications for wound healing, rehabilitation, and overall success in TKA. There is a need for more focused research integrating objective scar assessment tools and correlating them with functional and surgical outcomes. Clarifying these associations could support standardized closure protocols that enhance both short-term and long-term recovery in TKA patients.

Keywords: TKA, Wound-Healing, Scar Contracture, Arthroplasty, Postoperative

List of Abbreviations:

TKA	:	total knee arthroplasty
SSI	:	surgical site infection
PJI	:	periprosthetic joint infection
RCT	:	randomized control trial
PDGF	:	platelet-derived growth factor
TGF-β	:	transforming growth factor-beta
VEGF	:	vascular endothelial growth factor
bFGF	:	basic fibroblast growth factor
EPCs	:	endothelial progenitor cells

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NSAIDs	:	nonsteroidal anti-inflammatories
SKINTED	:	Surgical Knee Injury-Related Neurogenic Eczematous Dermatitis
ROM	:	range of motion
PROs	:	patient-reported outcomes
POSAS	:	Patient and Observer Scar Assessment Scale
BMI	:	body mass index

Introduction

Total knee arthroplasty (TKA) is a widely used orthopaedic treatment aimed at improving knee function and reducing pain in patients with osteoarthritis or other traumatic injuries. Annual TKA operations in the U.S. are expected to reach 3.5 million by 2030, emphasizing the need for optimized postoperative care and complication prevention [1]. Multiple postoperative complications impact the success of TKA procedures. The surgical technique for superficial skin closure influences postoperative wound healing as well as cosmetic results, patient satisfaction, and surgical site infection (SSI) risk [2]. Poor skin healing can result in deeper tissue complications, such as periprosthetic joint infections (PJIs), which can lead to prolonged hospitalizations and revision surgeries [3]. Additionally, patient-specific factors, surgeon preference, and facility costs influence the selection of closure techniques. Patient outcomes in wound healing are affected by various comorbidities, including diabetes mellitus, peripheral vascular disease, and obesity [4].

The superficial closure methods for wound management include interrupted or continuous sutures, staples, tissue adhesives, and barbed sutures [5]. These techniques present distinct benefits and disadvantages when evaluating infection risk, tensile strength, closure time, cost-effectiveness, and ease of removal. For example, staples used in hip and knee arthroplasty closure are associated with a greater risk of SSIs compared to suture-based methods [2]. Metallic staples are preferred for their strength but can lead to higher infection rates and poorer cosmetic outcomes compared to subcuticular sutures [2]. The use of absorbable sutures can lead to better patient outcomes while reducing the chance of infection. However, the mechanical strength of these sutures can lead to possible complications. This review analyzes the risks and benefits of different superficial skin closure techniques for TKA to evaluate their effects on postoperative wound healing. A combination of results from randomized controlled trials (RCTs), meta-analyses, and cohort studies is used to evaluate closure technique safety and effectiveness while providing practical applications for clinical practice.

Methods

A comprehensive literature review was conducted to examine skin closure techniques for total knee arthroplasty with outcomes on postoperative wound healing. The potential risks, benefits, challenges, and alternatives associated with different skin closure techniques were assessed. This review identified relevant studies through a systematic search of PubMed, Google Scholar, and other scientific databases. Key search terms included "total knee arthroplasty," "skin closure," "sutures," "staples," "wound complications," "wound healing," and combinations of these keywords. The search conducted by the authors was restricted to peer-reviewed journal articles, clinical trials, literature reviews, and meta-analyses published in English. The data synthesized by these studies provided a comprehensive review of different skin closure techniques for total knee arthroplasty, while also focusing on identifying gaps in the current research, and areas for future investigation.

Overview of Wound Healing Physiology

Cellular & Molecular Stages of Wound Healing

Wound healing progresses through three overlapping phases: inflammation, proliferation, and remodeling.

Inflammation Phase

Immediately following injury, platelets aggregate at the wound site and release growth factors such as platelet-derived growth factor (PDGF) and transforming growth factor-beta (TGF-β), which initiate the inflammatory cascade [6]. Neutrophils are the first to arrive, clearing pathogens and debris through phagocytosis and releasing reactive oxygen species and pro-inflammatory cytokines [7]. Within the first 48–72 hours, macrophages replace neutrophils, orchestrating the transition to repair by releasing cytokines and growth factors that stimulate angiogenesis and cell recruitment [8]. This phase establishes the cellular environment necessary for tissue regeneration in the subsequent proliferation phase. Effective coordination of these immune responses is essential; dysregulation at this stage can lead to chronic inflammation and delayed healing. The duration and intensity of the inflammatory phase must be tightly controlled to balance microbial defense with timely progression toward tissue repair.

Proliferation Phase

Angiogenesis, primarily stimulated by vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF), restores perfusion to the injury site, while vasculogenesis, mediated by endothelial progenitor cells (EPCs), supports new vessel formation in hypoxic conditions [9]. EPC mobilization is facilitated by nitric oxide, VEGF, stromal derived factor 1-alpha, and matrix metalloproteinases, ensuring delivery of nutrients, gases, and metabolites via the new vasculature [10,11]. Fibroblasts then migrate to the wound bed and deposit a provisional extracellular matrix composed of type III collagen, glycosaminoglycans, and fibronectin, forming granulation tissue [6,12]. These events mark a critical transition from immune activity to tissue reconstruction. Insufficient vascularization or fibroblast dysfunction at this stage can impair healing and predispose the wound to chronicity.

Remodeling Phase

Approximately three weeks post-injury, type III collagen is gradually replaced by stronger type I collagen to enhance tensile strength in the maturing extracellular matrix [13]. Fibroblasts differentiate into myofibroblasts under the influence of TGF-B, generating contractile forces that support ECM remodeling [14]. Myofibroblasts typically undergo apoptosis after wound closure; persistent activity can result in hypertrophic scarring or fibrosis [14]. As the tissue remodeling progresses, angiogenesis subsides, and the scar that remains lacks rete ridges - epidermal projections into the dermis that provide structural integrity and resistance to shear forces [12]. The absence of rete ridges compromises the mechanical resilience and flexibility of scar tissue over highly mobile joints like the knee. In TKA, optimal skin closure techniques should account for this by promoting uniform healing and minimizing tension to reduce the risk of dehiscence, poor cosmesis, and wound complications.

Factors Influencing Healing Including Surgical Closure

Wound healing depends on adequate blood flow, oxygenation, nutrient availability, balanced inflammation, and mechanical forces. As an energy-dependent process, it can be impaired by deficiencies in macronutrients and micronutrients such as vitamin C (collagen synthesis), vitamin A (epithelial growth and angiogenesis), and zinc (wound strength); however, supplementation offers little benefit in non-deficient individuals [15]. Smoking, peripheral artery disease, radiation history, and excessive alcohol intake impair circulation and immune function, disrupting healing [16-20]. Additionally, hyperglycemia in poorly controlled diabetes impairs fibroblast and endothelial cell function, further delaying repair [21]. These factors are particularly relevant in surgical populations, where addressing modifiable risks preoperatively may improve postoperative wound outcomes.

Medications such as nonsteroidal anti-inflammatories (NSAIDs) and chemotherapy can alter inflammatory pathways and impair healing, while excessive inflammation may promote fibrosis and scarring [22,23]. Aging also slows wound repair due to reduced collagen content and epidermal turnover [17]. The remodeling phase of wound healing is heavily influenced by extrinsic mechanical forces, including natural skin tension and suturing techniques that alter this tension. Mechanical forces that increase skin tension play a key role in tissue remodeling during wound healing, with wounds over joints like the knee prone to hypertrophic scarring due to continuous cyclical motion [24]. As such, surgical closure in TKA should optimize functional and cosmetic outcomes, minimize infection risk, and consider patient-specific factors such as diabetes mellitus, nutritional deficiencies, smoking, and other comorbidities.

Types of Superficial Skin Closure Techniques

There are multiple superficial skin closure techniques to optimize wound healing, cosmesis, and improve patient function. Table 1 summarizes key takeaways of each method.

Staple Closure

Staples offer a quick and efficient method for wound closure, particularly in orthopaedic surgery. Staples are synthetic materials that require future removal and do not require extensive training to apply or remove. They are frequently used in orthopaedic surgery, especially for managing longer incisions and traumatic wounds. However, staples are associated with an increased risk of infection, especially in closure of superficial tissue after hip or knee arthroplasty compared to sutures [25]. Additionally, staples increase the risk of scarring [26]. While staples have clinical utility, their risks of increased scarring and possible infection—especially in elective orthopaedic surgeries—should be considered.

Suture Closure

There are three common ways to classify the sutures: absorbable versus non-absorbable, natural versus synthetic, and monofilament versus multifilament.

Absorbable sutures: allow for deep, temporary support since skin macrophages eventually degrade them [27]. They are often used for deep wounds to approximate the edges in layers, helping to reduce skin tension. However, they can lead to increased inflammation, which has the potential to cause adverse superficial skin reactions, such as erythema at the incision site [28]. Another type of absorbable suture designed to reduce closure time is the self-retaining barbed suture, which contains spikes, barbs, or indentations that penetrate the skin. A 2024 systematic review regarding the use of barbed sutures and skin adhesives demonstrated that barbed sutures promote better tissue healing in hip and knee arthroplasty [29]. Moreover, the use of barbed sutures significantly reduced suturing and operating room time [29]. Additionally, no differences were found in reintervention rates, postoperative complications, or length of hospital stay after the procedure [30]. The use of barbed sutures has become important in both arthrotomy closure and the closure of overlying tissue [31]. They have been shown to reduce arthrotomy leakage and have a lower incidence of failure compared to other sutures, increasing their utility in areas like the anterior knee [32]. This allows the wound edges to have better contact, potentially lowering the risk of hypertrophic scarring, thus offering clinical utility in many orthopaedic surgeries.

Non-absorbable sutures: provide long-term support to optimize wound healing but require future removal. The use of absorbable sutures has been associated with a decreased risk of dehiscence compared to non-absorbable sutures [33].

Monofilament sutures: are smooth-surfaced filaments that cause less tissue trauma and are associated with a lower risk of bacterial infection, such as Monocryl [34]. Monofilament sutures can be an option for patients with wounds located in low-tension areas, since less resistance from the sutures is required.

Polyfilament sutures: are braided, multifilament threads associated with an increased rate of infection compared to monofilament sutures [27]. However, polyfilament sutures can be useful when closing areas with high mobility or stress due to their greater strength compared to monofilament sutures.

Tissue Adhesives

Adhesive Glues: (e.g., histoacryl glue) are commonly used for minor, superficial lacerations. The edges of the wound are approximated and held together before applying the adhesive to reduce superficial skin tension. These adhesives cause an exothermic reaction during polymerization [35]. Tissue adhesives are frequently used in the pediatric population because they are less time-consuming and less traumatic for the patient [36]. Adhesive glues are easy to apply and reduce operating room time. They often improve wound cosmesis by limiting superficial skin tension.

Novel techniques

Electrospinning: a pharmaceutical elution suture technology that allows surgeons to introduce fluids, such as antibiotics, into the wound and suturing materials, can help reduce complications like wound dehiscence and infections [37]. A 2022 study evaluating electrospun medical sutures for wound healing concluded that nanofibers prepared with electrospinning offer advantages due to their ability to incorporate bioactive substances into the polymer [38]. However, this method is not yet widely utilized and requires further investigation.

Table 1. Comparative summary of superficial skin closure techniques in total knee arthroplasty

Technique	Infection Risk	Scar Quality	Closure Time	Cost	High-Tension Suitability	Patient Satisfaction	Range of Motion (ROM) Impact
Staples	High	Poor (irregular, visible)	Fast	Low	Poor	Low	Limited (discomfort)
Subcuticular Sutures (Monofilament)	Low	Good (linear, flat)	Moderate	Moderate	Moderate	High	Neutral to Positive
Barbed Sutures	Low	Very Good (tight seal)	Fast	High	Excellent	Very High	Positive (less restriction)
Tissue Adhesives (e.g. 2-Octyl-Cyanoacrylate)	Low	Good (minimal trauma)	Fast	Moderate	Poor (for joints)	High	Neutral
Hybrid (Barbed + Adhesive)	Very Low	Excellent	Fast	High	Excellent	Very High	Positive (encourages rehab)
Electrospun Sutures	Promising (Experimental)	Potentially Excellent	Unknown	Unknown	High (potential)	Unknown	Unknown
Retention Sutures (for Obesity)	Reduced	Improved	Moderate	Moderate	High	High	Positive in High BMI

Dermatological Considerations in Postoperative Healing

Cutaneous Complications Overview

Various cutaneous complications can occur postoperatively following TKA. Skin necrosis may result from compromised perfusion, often exacerbated by excessive tension due to overly tight closures or underlying vascular insufficiency [39-41]. Additional wound-related issues include dehiscence, the separation of wound edges, and delayed healing, both of which can increase infection risk and complicate recovery [42]. These complications underscore the importance of both optimal surgical wound closure techniques and thorough preoperative risk assessment, especially in patients with poor vascular health or other comorbidities.

Hypersensitivity Reactions

Allergic reactions represent a distinct subset of postoperative cutaneous complications. One common manifestation is contact dermatitis, a T-cell mediated type IV hypersensitivity reaction triggered by adhesives, antiseptics, or other components of surgical dressings used in superficial wound closure [43]. Histologically, this condition is marked by spongiosis, epidermal edema, and lymphocytic infiltration [44]. Approximately 15–20% of the general population is sensitized to at least one common allergen, including nickel, fragrances, preservatives, and topical antibiotics like neomycin [45,46], making allergic contact dermatitis a frequent concern in postoperative care. A retrospective cohort study by Saleh et al. analyzed 3,275 knees postoperatively after TKA and identified that wound complications, including dermatitis, were significantly associated with increased rates of deep infection and poorer clinical outcomes, emphasizing the downstream impact of skin closure-related issues on prosthetic success [47]. These findings highlight the importance of selecting skin closure materials that minimize allergenic potential. Considering the critical role of the skin barrier in preventing postoperative infection, even subtle inflammatory responses from allergic contact dermatitis may serve as catalysts for more serious downstream complications.

Hypersensitivity reactions to implant materials, while less frequently encountered, are another important consideration. Metals such as nickel, cobalt, and chromium, commonly found in prosthetic components, can elicit delayed-type hypersensitivity responses. These reactions involve antigen-specific T-cells reacting to metal-protein complexes, resulting in local inflammatory responses or systemic cutaneous symptoms [48]. The prevalence of metal hypersensitivity in the general population is estimated at 10–15%, with a potentially higher incidence in patients presenting with unexplained pain, dermatitis, or implant failure postoperatively [49,50]. In the context of this review, these immunologic reactions highlight the need for thoughtful selection of skin closure materials and techniques that minimize allergen exposure, particularly in patients with known sensitivities, as part of a comprehensive strategy to optimize wound healing following TKA.

A more specific and under-recognized dermatologic complication associated with TKA is Surgical Knee Injury-Related Neurogenic Eczematous Dermatitis (SKINTED), a form of localized eczematous dermatitis resulting from autonomic denervation to the infrapatellar branch of the saphenous nerve [51,52]. SKINTED typically presents as persistent, well-demarcated, itchy, and scaly plaques along the medial aspect of the knee, often resembling chronic eczema [53]. Notably, it may not appear until months or even years after surgery, which can make the diagnosis challenging and lead to misclassification as a primary dermatologic disorder [52]. Its chronicity and delayed onset may lead to misdiagnosis as atopic or contact dermatitis, potentially resulting in unnecessary treatments or overlooked surgical history.

Scar Contracture

Scar contracture is a significant postoperative complication following TKA, characterized by excessive fibrosis and contraction of periarticular tissues, leading to restricted range of motion (ROM), pain, and functional limitation. This occurs when wound healing is disrupted by chronic inflammation or excessive mechanical tension, prompting fibroblast differentiation into myofibroblasts and promoting pathological collagen deposition [54,55]. In TKA patients, this can manifest as arthrofibrosis, an intra-articular form of scar contracture that occurs in approximately 3–10% of cases [56,57]. Histologic studies have shown that patients undergoing revision TKA demonstrate elevated fibrotic signaling in the synovium and infrapatellar fat pad compared to those undergoing primary procedures, indicating a cumulative fibrotic process [58,59]. Known risk factors for arthrofibrosis include prior surgeries, limited postoperative mobilization, and individual fibrotic tendencies. This condition not only impairs postoperative recovery but may also require additional interventions, including manipulation under anesthesia or surgical lysis of adhesions [57,60,61]. As full flexion and extension are critical measurements of TKA success, even modest scar contracture can significantly compromise long-term function. Understanding these biological processes is essential for preventing fibrosis-related complications. Ultimately, targeting inflammation and tension at the wound site may be a key strategy to minimize arthrofibrosis risk and improve clinical outcomes.

Comparative Clinical Outcomes

Infection Rates and Wound Complications

Infection following total knee arthroplasty (TKA) is a serious complication, as superficial wound infections can progress to deep periprosthetic joint infections (PJIs) and prolonged morbidity. The superficial skin closure technique plays a critical role in minimizing this risk. However, existing studies present conflicting data regarding the incidence of wound infections associated with staples versus sutures. A meta-analysis by Smith et al. revealed a higher incidence of superficial wound infections in patients closed with staples following TKA, a finding echoed by Newman et al. in a large retrospective analysis [25,62]. Similarly, Vogt et al. observed increased rates of superficial skin necrosis and infection with staples, attributing these outcomes to poor wound edge approximation and greater tissue trauma [26]. These findings raise concerns about the routine use of staples in TKA, particularly when considering infection-sensitive populations. The consistent association between staples and higher infection rates suggests that alternative closure methods may offer safer outcomes, especially in patients with compromised healing potential. In contrast, a 2013 pilot randomized controlled trial by Slade et al. found no significant difference in surgical site infection rates between sutures and staples, suggesting that infection risk may depend on additional factors beyond closure type alone [63]. Nevertheless, subcuticular sutures—particularly those using monofilament or barbed absorbable materials—have recently been shown to offer a tighter skin seal and reduced bacterial ingress compared to staples [27]. Supporting this, a randomized clinical trial by Wyles et al. demonstrated that running subcuticular closure provided significantly higher mean incision perfusion, as measured by fluorescence imaging software, compared to vertical mattress and staple closures [64]. Collectively, these findings support the growing preference for advanced suture techniques in high-tension or cosmetically sensitive areas. Enhanced tissue perfusion and skin integrity not only lower infection risk but also promote more favorable recovery trajectories, emphasizing the value of selecting closure methods that optimize both biological and functional healing outcomes.

Moreover, recent investigations have focused on the comparative efficacy of monofilament versus braided suture materials, as well as emerging technologies like barbed sutures, in optimizing wound healing and minimizing infection risk. Historically, monofilament sutures used in the subcuticular skin layer have offered superior wound approximation and a lower risk of bacterial colonization compared to multifilament sutures, which can harbor bacteria due to their braided structure [27]. However, a randomized controlled study by Wongsak et al. reported no differences in rates of surgical site infections (SSIs) when comparing monofilament sutures and braided sutures [65]. Furthermore, recent interest in barbed sutures shows promise in terms of wound integrity and consistent healing. Findings by Romanini et al. suggest that barbed sutures, particularly in combination with tissue adhesives, improve skin integrity by optimizing vascular perfusion, thus minimizing infection risk [29]. Nonetheless, Sarhan et al. concluded that their association with infection rates remains comparable to conventional techniques [30]. Harshvardhan et al. recommended against the use of barbed sutures for subcuticular layer closure, specifically in unicompartmental knee arthroplasty [66]. Moreover, the use of tissue adhesives, such as Histoacryl, has shown promise for creating a bacteriostatic barrier in clean surgical wounds, though their mechanical integrity in high-movement areas remains debated [67].

These findings underscore the need for wound closure strategies that minimize wound gaps and tissue inflammation while ensuring tissue integrity in high-tension areas like the anterior knee. More high-quality randomized controlled trials are needed to delineate the relationship between various superficial skin closure techniques of the anterior knee incision in TKA and the risk of wound complications.

Wound Dehiscence and Delayed Healing

Wound dehiscence and delayed healing following TKA impair rehabilitation and may necessitate reintervention. The method of superficial closure directly affects wound tension distribution and tissue perfusion. Staples, while time-efficient, have been associated with increased wound edge separation and delayed epithelialization in TKA patients [26]. Sutures—especially subcuticular techniques using monofilament or barbed materials—allow for more even tension distribution across the wound. A meta-analysis by Sajid et al. concluded that absorbable sutures were associated with lower dehiscence rates compared to non-absorbable ones in skin closure [33].

Barbed sutures, due to their unidirectional tension distribution and self-retaining design, have been shown to reduce the incidence of dehiscence in TKA. In particular, Romanini et al., Kobayashi et al., and Sarhan et al. reported enhanced tissue watertightness and improved healing outcomes with barbed sutures, attributing their benefits to continuous force distribution and decreased knot-related tension points [29,30,68]. Their results also suggested that tissue adhesives alone are insufficient to resist the tension from underlying joint movement in TKA but show benefit when used as adjuncts, reducing minor gapping when layered over barbed sutures [29]. Conversely, interrupted sutures and staples create focal tension points that may compromise skin perfusion, increasing the risk of ischemia and subsequent dehiscence [31]. These findings underscore the importance of selecting closure methods, such as barbed or continuous subcuticular sutures, that are better suited for dynamic, high-tension anatomical regions.

Postoperative Range of Motion

Postoperative range of motion (ROM) in TKA is influenced by the quality and security of wound closure. Inadequate closure can restrict movement due to pain, scar contracture, or other wound complications. While staples provide mechanical strength, they tend to restrict mobility due to rigid skin edge approximation and are more prone to cause subjective discomfort during movement [26]. In addition, Eggers et al. compared staples, subcuticular sutures, and tissue adhesives in TKA and found no statistically significant differences in ROM at six weeks or three months [69]. However, patients in the adhesive and suture groups reported greater comfort and less skin irritation—factors that may encourage earlier participation in physical therapy [69]. Together, these findings suggest that ROM outcomes are multifactorial in nature, determined not only by the closure material but also by factors such as patient comfort and the overall rehabilitation experience. Similarly, a 2020 study by Chen et al. comparing running subcuticular closure with intermittent silk sutures found no significant difference in six-month postoperative ROM between the groups, though patients receiving subcuticular closure reported greater satisfaction, likely due to improved cosmetic outcomes [70]. These findings suggest that while mechanical ROM outcomes may appear similar across closure techniques in the medium term, patient-centered metrics—such as pain perception, ease of movement, and satisfaction—may have a meaningful impact on functional recovery.

Barbed sutures have been proposed to improve wound closure consistency and minimize tissue trauma. Sartawi et al. described a “watertight closure technique” using barbed sutures in TKA, emphasizing early rehabilitation and reduced wound drainage. Although specific ROM metrics were not reported, the authors highlighted improved patient comfort and wound integrity, both of which are key enablers of early joint motion [71]. Vakil et al. further supported this by demonstrating superior resistance to flexion-induced mechanical stress in barbed versus interrupted biodegradable sutures in a biomechanical cadaveric model, suggesting greater durability in high-motion joints like the knee [31]. These findings suggest that barbed sutures may offer enhanced mechanical resilience and improved wound integrity in TKA, potentially facilitating earlier mobilization and better functional outcomes.

Scar contracture at the skin level—particularly along the anterior knee incision—may act as a mechanical constraint that restricts soft tissue mobility and exacerbates fibrotic processes deeper in the joint, such as arthrofibrosis. Arthrofibrosis is a complex, multifactorial complication of TKA, commonly associated with poor intraoperative soft tissue balancing, limited preoperative ROM, prior knee surgeries, and delayed postoperative mobilization [60,72]. Approximately 1.3–5.3% of patients develop arthrofibrosis after primary TKA, while revision surgery for arthrofibrosis occurs in 4% to 18% of cases [73-75]. While intra-articular causes are well characterized, the potential contribution of superficial scar behavior—shaped by skin closure technique—remains underexplored. The staple closure method has been associated with increased wound tension, pain, and hypertrophic scarring, which may discourage early rehabilitation [26, 62]. In contrast, subcuticular sutures and hybrid suture-adhesive systems may reduce skin irritation and support earlier mobilization, potentially lowering the risk of postoperative stiffness [70,71]. Though a direct causal link between skin closure type and arthrofibrosis has not been established, the relationship between scar contracture, patient comfort, and joint motion suggests a plausible connection. Further research is warranted to clarify whether optimizing skin-level healing can help prevent deeper fibrotic complications following TKA.

Patient Satisfaction and Reported Outcomes

Patient satisfaction following TKA is multifactorial, influenced by functional recovery, pain levels, the cosmetic appearance of the surgical site, and the ease of wound care. Among these, the method of superficial skin closure has increasingly been recognized as a variable that affects both cosmetic satisfaction and overall patient experience. Closure with metal staples, while efficient, has been consistently associated with dissatisfaction due to more visible, irregular scars and greater discomfort during removal [76]. In a randomized controlled trial, Nepal et al. found that patients whose incisions were closed with subcuticular sutures reported significantly higher satisfaction scores and more favorable cosmetic outcomes compared to those who received staples [77]. Taken together, these results suggest that while staples are efficient, they may compromise patient-centered outcomes.

Barbed sutures, which have gained popularity in arthroplasty, offer the advantage of knotless closure and uniform tissue tension distribution, potentially reducing skin irritation. A systematic review and meta-analysis by Raja et al. demonstrated that barbed sutures reduced wound closure time without increasing complication rates, suggesting potential benefits in both efficiency and patient satisfaction [78]. Interestingly, Sartawi et al. noted that barbed suture closure reduced the need for bulky dressings and promoted earlier wound exposure, which some patients preferred for comfort and convenience [71]. Hence, while cosmetic outcomes are not the sole determinant of patient satisfaction, they have a growing influence in modern orthopaedics, particularly among younger or more active patients.

Innovative closure devices, such as the Zip surgical skin closure system, have also been assessed for their impact on scar cosmesis. In a randomized prospective study, patients closed with the Zip system reported higher satisfaction and better cosmetic outcomes compared to those closed with staples [79]. Closure techniques that minimize pain, reduce dressing requirements, and enhance scar appearance—especially barbed sutures and hybrid adhesive techniques—are increasingly associated with favorable patient-reported outcomes.

Cost and Efficiency in Hospital and Clinical Settings

In high-volume orthopaedic practices, the efficiency and cost-effectiveness of skin closure methods are critical considerations. While staples are quick to apply, they have been associated with higher rates of superficial wound infections, potentially leading to increased downstream costs [25,30]. Thus, the orthopaedic surgeon must balance the cost and efficiency of wound closure when selecting the method for anterior knee incision closure.

Barbed sutures, while more expensive per unit, have been shown to reduce operative time and be more cost-effective than traditional subcuticular sutures in TKA [80,81]. Similarly, the Zip surgical skin closure device has demonstrated potential cost benefits due to reduced need for dressing changes and follow-up visits [79]. Tissue adhesives, particularly 2-octyl cyanoacrylate, have been associated with reduced postoperative wound drainage and dressing changes, shorter hospital stays, and lower overall wound care costs compared to n-butyl-2 and no adhesives [80]. In their study, Eggers et al. compared four wound closure methods in TKA—staples, subcuticular sutures, and two types of tissue adhesives (2-octyl and n-butyl-2-cyanoacrylate)—finding that staples had the fastest closure time, followed by the tissue adhesives, and finally subcuticular sutures [69]. Correspondingly, closure costs per centimeter were highest for sutures and tissue adhesives and lowest for staples [69].

In summary, while traditional staples offer the fastest closure time and lowest immediate material costs, alternative methods like barbed sutures and tissue adhesives may provide better overall cost-efficiency by reducing operative time, postoperative complications, and the need for follow-up wound care. These benefits are particularly relevant in high-volume orthopaedic practices, where efficiency is paramount to patient outcomes.

Challenges and Future Directions

Long-term Follow-up Studies

Despite advancements in superficial wound closure techniques following total knee arthroplasty (TKA), several critical gaps remain that hinder the development of standardized, evidence-based protocols. Most current studies emphasize short-term outcomes, such as wound integrity and cosmetic appearance, while long-term data on superficial wound closure in TKA are limited. Important factors, such as infection rates, scar quality, healing durability under mechanical stress, and overall functional recovery, are often underexplored. This lack of long-term follow-up is notable, as complications like hypertrophic scarring, wound dehiscence, and unsatisfactory cosmetic results often arise after the initial 90-day postoperative window. Liu et al. reported favorable early scar outcomes using 2-octyl cyanoacrylate adhesives in a multicenter trial [80]. However, the limited follow-up period of three months postoperatively restricts conclusions regarding long-term scar healing and patient outcomes [80].

Long-term follow-up is essential to account for healing under mechanical stress during full activity in postoperative TKA patients. Chen et al. partially addressed this issue with a six-month follow-up period comparing subcuticular versus intermittent closure techniques [70]. They noted improved cosmetic satisfaction in the subcuticular group. However, their comparison of infection-related inflammation markers was limited to one month postoperatively and showed no significant differences. Similarly, Kong et al. demonstrated that promising closure techniques, such as tissue adhesives, require further validation through studies with longer follow-up periods to properly assess infection rates, readmissions, and scar remodeling over time. Some studies have reported extended follow-up periods. For example, Agarwala et al. followed patients for over one year using a concealed cosmetic closure technique in TKA and reported superior long-term patient satisfaction [81]. However, the lack of correlation between aesthetic outcomes and other recovery metrics, such as infection rates, range of motion, or return to function, underscores the need for more comprehensive long-term studies integrating both cosmetic and functional measures. Guirro et al. further highlighted this disconnect by showing that well-managed superficial wound infections did not impact implant longevity [82]. However, their analysis focused on infection management rather than the role of skin closure techniques, reinforcing the need for long-term studies exploring the relationship between superficial wound closure methods and broader healing outcomes.

These findings emphasize the need for extended investigations into the impact of superficial wound closure techniques not only on aesthetic outcomes, but also on infection rates, scar quality, healing durability under mechanical stress, and overall functional recovery.

Integration of Patient-reported Outcomes

Patient-reported outcomes (PROs) are increasingly recognized as vital components in clinical research and healthcare due to their ability to capture patients' perspectives on symptoms, quality of life, and overall health status. Although clinical outcomes remain important, such as infection rates or wound dehiscence, they do not fully reflect the patient experience. Postoperative pain levels, scarring discomfort, skin stiffness, and cosmetic dissatisfaction can influence rehabilitation, shape a patient's perception of surgical success, and affect postoperative quality of life.

Zhou et al. applied the Patient and Observer Scar Assessment Scale (POSAS) and found that patients rated barbed suture closures more favorably than conventional methods, citing better appearance and comfort [80]. This highlights the importance of incorporating PROs, especially those focused on postoperative scar discomfort and cosmetic appearance, into the evaluation and selection of wound closure techniques. In a similar study, Liu et al. used both POSAS and Vancouver Scar Scale metrics and demonstrated superior scores for 2-octyl cyanoacrylate adhesives compared to n-butyl adhesives and staples, further supporting the use of tissue adhesives for enhancing patient satisfaction as measured by PROs [81].

Menkowitz et al. demonstrated the value of PROs in assessing subjective patient metrics, such as scar appearance, pain, itching, color, stiffness, thickness, irregularity, vascularity, pigmentation, relief, pliability, and surface area [79]. Patients favored the Zip surgical skin closure system over staples, reporting reduced discomfort and more favorable cosmetic results. These findings emphasize the importance of incorporating validated PROs into future research to ensure that patient perspectives are fully considered.

Innovation in Closure Materials

Innovations in closure materials have introduced new possibilities for improving wound healing outcomes after TKA. Barbed sutures, cyanoacrylate adhesives, and non-invasive closure devices have each demonstrated benefits in early studies, including shorter closure times and improved cosmetic results [80-84]. Shorter closure times have also contributed to reduced operating costs [85]. The use of bidirectional barbed sutures instead of traditional sutures makes TKA more cost-effective by significantly reducing closure time and decreasing wound closure complications [85].

Future research into innovative closure materials could further optimize surgical outcomes and help reduce complications, such as wound dehiscence, infection, and excessive scar formation. Additionally, exploration into specialized techniques for specific patient populations has shown promise. Rajani et al. demonstrated that using retention stitches in superficial wound closure for TKA patients with a body mass index (BMI) greater than 30 reduced postoperative complications, such as wound dehiscence, localized skin necrosis, and stitch cut-through [86]. Their long-term follow-up, ranging from six months to five years, provides meaningful insight into the sustained success of innovative approaches [86]. As the role of superficial wound closure in TKA is explored further, future studies should prioritize long-term outcomes, patient-reported satisfaction, and innovative closure materials that address postoperative wound healing complications.

Conclusion

Superficial skin closure techniques in total knee arthroplasty (TKA) play a pivotal role in postoperative wound healing and complication rates. Techniques, such as subcuticular sutures, hybrid barbed sutures, and adhesive systems have demonstrated superior outcomes compared to metallic staples, including reduced wound dehiscence, enhanced scar quality, and higher patient satisfaction. However, current literature is limited by a predominant focus on short-term outcomes, such as wound closure time, infections, and wound dehiscence. There remains a lack of robust data on delayed wound healing processes, functional rehabilitation, and long-term scar development. Additionally, outcome reporting is often inconsistent, with variable use of validated scar assessment tools, such as the Patient and Observer Scar Assessment Scale (POSAS), making cross-study comparisons challenging. Highly mobile and weight-bearing joints, such as the knee, are particularly vulnerable to wound healing complications. However, many studies do not adequately account for patient-specific risk factors, including obesity, diabetes mellitus, and dermatologic histories. Given these concerns, staple usage in TKA wound closure should be approached cautiously, especially in patients at higher risk of wound complications or those with heightened cosmetic concerns. The documented benefits of absorbable subcuticular sutures and novel tissue adhesives, such as reduced superficial complications and enhanced scar appearance, support their broader adoption in TKA. These methods also offer practical benefits, including fewer dressing changes and improved patient comfort during recovery.

This review underscores the need to develop patient-specific selection criteria for skin closure techniques. For example, individuals with obesity may benefit from retention sutures or reinforced closure strategies, while younger or more active patients may prioritize cosmetic results and comfort during rehabilitation. The selection of surgical closure strategies must be guided by factors such as body mass index (BMI), medical comorbidities, and skin integrity. Ultimately, wound management in TKA could benefit from evidence-based protocols for skin closure. Future research should prioritize multicenter randomized controlled trials with extended follow-up periods and patient-reported outcome measures. These trials should also evaluate the cost-effectiveness and clinical performance of antimicrobial-coated barbed sutures and hybrid closure systems. Optimizing skin closure techniques in TKA is critical for minimizing surgical complications, such as infection and wound dehiscence, and supporting early mobilization to enhance long-term functional recovery.

Figure Captions

Table 1. Comparative summary of superficial skin closure techniques in total knee arthroplasty (TKA).

This table presents a comparative overview of the main superficial skin closure techniques used in TKA, highlighting general trends in infection risk, scar quality, closure time, cost, suitability in high-tension areas, patient satisfaction, and expected range of motion (ROM) outcomes. These are general principles based on the literature reviewed and are intended to summarize key takeaways, especially where clinical data (e.g., electrospun sutures) is still emerging. Abbreviations: ROM = range of motion; BMI = body mass index.

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