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Review Article

Innovative Wound Closure: The Role of Zipper Device in Modern Surgery

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ABSTRACT

The surgical zipper skin closing device offers a non-intrusive, sterile, atraumatic, hypoallergenic, and hydrophobic approach for closing the surgical wounds. This zipper-like, non-invasive dressing utilizes two hydrocolloid adhesive strips to gradually close incisions. Surgical zippers are available in seven sizes, suitable for wounds between 4cm and 47cm. Compared to conventional methods like sutures and staples, zip-type closures provide numerous benefits, including ease of use, higher success rates, minimized tension, and lower infection rates. They also offer superior cosmetic results and faster healing due to stress distribution and gentle compression. The device is needle-free and sharp-free, eliminating skin puncture risks. It significantly reduces wound closure time (e.g., the Medizip system reduces closure time to 2-2.3 minutes compared to 9.4 minutes with sutures). Surgical zippers are effective in various surgical scenarios, including orthopedic, neurosurgery, obstetric, and cardiovascular procedures, and can even be used in non-sterile settings. Patients report greater satisfaction due to enhanced comfort and aesthetics, and the device can reduce the need for additional procedures, shorten hospital stays, and save time. Cosmesis outcomes show that zip closures receive higher ratings in scar appearance across multiple factors compared to traditional methods. Despite its advantages, the uptake of surgical zippers remains limited in some areas. Future advancements aim to optimize designs and material properties. The main disadvantage lies in their ineffectiveness in high-tension areas or areas with constant movement. Ultimately, surgical zip-type closures are expected to evolve into specialized tools tailored for distinct surgical requirements, expanding their use in modern surgical practices.

INTRODUCTION

Professor H.Y. Kaessman was the first to develop a surgical medizip wound closing device in the

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year 1989 in Germany [1]. Zip-type wound closure device is a non-invasive novel approach for lacerations and surgical wounds, which are sterile, atraumatic, hypoallergenic, and hydrophobic in nature. The incision is secured with two hydrocolloid adhesive strips, composed of a blend of micro-porous polyester and acrylate adhesive that is applied to both sides of the superficial skin. This forms a zipper-like, non-invasive dressing, which allows for the gradual closure of the incision by gently pulling the straps[2]. It works well for incisions that are straight or slightly curved. Surgical zippers are offered in seven different sizes, ranging from 6cm to 50cm, and are well-suited for closing wounds that measure between 4cm and 47cm[3]. The zipper application requires 2-4 cm extension beyond the wound, maintaining a 0.5cm distance between the zipper teeth and the incision margin [4].

The zip tie wound closure device seems to provide several benefits compared to conventional techniques, such as ease of use, a higher success rate in surgical operations, a lower risk of pressure necrosis, and reduced tension. The zigzag linkage also provides gentle compression, promoting healing. The zigzag linkage also provides gentle compression, promoting healing. Notably, this device is needle-free and sharp-free, eliminating the risk of skin puncture. When compared to traditional methods, this zip method is a simple, easy, but effective system that distributes the stress homogeneously across the wound region, at the same time it provides superior cosmetic results and quick action [5]. Its tensile and adhesive strength make it a promising solution for reducing the pain and pressure, especially when pressed against the body in various positions [6].

The zip tie wound closure device appears to offer numerous advantages over traditional methods, including ease of application, an increased success rate in surgical procedures, reduced risk of pressure necrosis, and minimized tension. The device significantly reduces the risk of infection while promoting effective healing by securely aligning wound edges together. Its strong grip and customizable design allow it to fit various wound types and locations, supporting uninterrupted healing and proper airflow. This supports faster tissue healing and leads to cleaner, more aesthetically healed scars. Patients frequently express greater satisfaction due to enhanced comfort and aesthetics.

With its high tensile strength providing reliable closure, the device can also cut down on the need for additional procedures, shorten hospital stays, and save time for both patients and healthcare providers [7]. It encompasses a wide range of surgical methods that employ flat incisions, covering orthopedic surgeries (such as knee and hip replacements), neurosurgery (pertaining to the spinal cord), obstetric operations (like caesarean sections), and cardiovascular surgeries (which include open-heart procedures). Furthermore, it operates efficiently under difficult circumstances, including non-sterile settings, and is especially advantageous for patients who need a longer time for wound closure or are more susceptible to healing complications. This method's versatility and effectiveness make it a valuable asset in diverse surgical scenarios[8].

The surgical zipper has gained international recognition and appreciation among patients and medical professionals alike. Nonetheless, its uptake continues to be restricted in our area, despite its benefits [1]. The main goal is to explore the latest innovation in surgical zipper and their role in modern surgical practices.

Invasive wound closure:

Sutures and staples represent the conventional techniques for closing skin incisions. Both methods facilitate wound closure by aligning the skin edges during the healing process. The practice of suture has been followed for thousands of years [11]. While sutures are reliable, they demand more time and expertise. In contrast, staples offer a faster alternative; nevertheless, they can lead to more significant tissue injury, inadequate wound closure, reduced mobility, and heightened pain for patients [7]. Using metal staples to close a wound might lead to a higher chance of infection and may not look as good cosmetically when compared to traditional sutures. They can also end up being more expensive [12]. When treating skin wounds, the focus is on closing them quickly, avoiding complications, and making sure they heal with minimal scarring for a better appearance. Thus, zip tie helps to simplify wound care and address many of the challenges associated with traditional stitches, leading to smoother healing and better outcomes for patients [13].

Non–invasive wound closures:

This method is widely used to close surgical cuts or wounds from injuries without using any needles or staples [7]. The zip device is designed to adapt to various skin types, providing a tailored fit that meets the specific requirements of each patient.

Incision closure duration: Utilizing the zipper device for skin closures. Time speeds up by cutting down the time for about 4.9minutes when compared to sutures [13].

Wound infection: Zip ties assist in decreasing the likelihood of wound and surgical site infections, leading to a 37% reduction in bacterial infections when compared to conventional sutures [7].

Wound approximation: Zip tie closes the wound gaps properly by preventing dehiscence and strain on wound edges. Sutures need supplemental devices such as a tension offloading device and tension shielding hydrogel system for tension reduction, whereas zip ties are self-sufficient [7].

Blister formation and accidental removal: The studies conducted by Oshan et al demonstrated that utilizing the fixed effect model, which indicates no significant difference in the formation of blister or vesicle. The chances of accidental removal of the zipper device were considered to be least [13].

Cosmesis outcomes: Bruce et al. demonstrated that significant difference in scar appearance in patient and observer scar assessment scale (POSAS). Zip closures received a higher POSAS rating across multiple factors, including color, stiffness and pliability as well as overall observer opinion [14]. In a study from Nigeria, Onuminya et al. It was found that nearly 90% of people who had the Medizip surgical zipper procedure formed tidy and slim scars, which were considered "positive results"[7].

Zip tie design: the zipper device is designed with adjustable coaptive strips that stick to the skin using a gentle hydrocolloid adhesive. Built-in ratcheting straps provide even, secure closure along the entire length of the incision, effectively off-loading tension and providing gentle compression at the wound edges. This design is intended to isolate the wound and redirect stress away from the incision, which can be advantageous during activities such as knee flexion [5].

There are four distinct types of zip tie closures: Normal Zipline Closure, Zigzag Zipline Closure, Medizip, and Zipfix Closures.

The non-invasive Zipline suture features a straightforward design, comprising two layers of

polyurethane elastic films that are coated with hydrocolloid adhesive both beneath and surrounding the suture area. These are equipped with several nylon locks and straps; these strips help to draw the edges of the wound together, ensuring a flexible yet secure closure [8].

The zip wound closure's zig-zag design offers a cutting-edge solution for wound management by gently bringing the skin edges together with its zipper-like design. The device helps create ideal healing conditions and may lead to minimal scarring [7].

The Medizip system incorporates a zipper that is embedded within a hypoallergenic, micro-porous polyester fabric, complemented by non-irritating fabric strips and aeration holes, all firmly held in place with acrylate adhesive to ensure a gentle yet effective closure of wounds. When using Medizip, make sure the device is about 2 to 4 cm longer than the wound, with the zipper teeth placed roughly 0.5cm away from the wound edges [9]. The Medizip system significantly reduced wound closure time to around 2–2.3 minutes, compared to 9.4 minutes with sutures [7].

The Zipfix system features two adhesive strips that secure to the skin on either side of the wound. A simple slider makes it easy to zip the strips together, ensuring a tight and secure closure. It has demonstrated encouraging outcomes in minimizing bacterial infiltration and complications following surgery [10] .

Innovative applications in advanced surgical methods: -

Orthopedic surgery: Orthopedic surgery entails the use of sutures to properly align the edges of an incision, ensuring that a gap of 4-5mm is preserved. Clean and dry the skin for proper device adhesion. Gently press down to attach the base of the zip device securely. Secure the strap with suitable tension to approximate wound edges. Pull the straps to bring the incision edges together. Secure the device by zipping it up after the suction drain has been removed, which is usually done around 10days post-surgery [15]. The zipper is generally taken out between 10 to 14 days following the surgical procedure. Zip surgical closures are utilized in various orthopedic procedures, including hip surgeries, total knee arthroplasty, spinal operations, and upper limb surgeries [12] [4].

Cardiovascular surgery: Following heart surgery, the incision was meticulously sealed using a unique zipper-like apparatus known as Zip surgical skin closure. To keep the area clean and protected, sterile gauze was applied. After a week, the device was gently removed with a specialized adhesive remover, which ensured minimal discomfort and protected the skin. Zip surgical skin closure is a safe and effective tool for closing wounds as well as shortening the time of wound closure in congenital heart patients after median sternotomy cardiovascular surgery [17]. The zipper device remained in position and was not opened until its planned removal, which took place 12 days following its application [4].

Minimally invasive surgery: Minimally invasive surgeries significantly benefit from the enhanced precision and decreased tissue damage afforded by specialized zip tie closures. These devices prove particularly advantageous in situations characterized by restricted space and visibility, where the use of precise tools is essential. Their ability to securely approximate tissue and control bleeding contributes to improved surgical outcomes [7].

Robotic-assisted surgeries: These procedures are characterized by their high precision, and the use of optimized zip ties can enhance their

effectiveness. When integrated with robotic systems, zip ties contribute to improved surgical accuracy and efficacy in prostate cancer operations. The combination of zip ties and robotic instruments allows for meticulous handling and improved access to challenging regions, thereby expanding the range of procedures that can benefit from this technology. Localized prostate cancer is often addressed through robot-assisted medical prostatectomy [16].

Specific Anatomical Procedural Examples:

i) In the case of reconnecting tubular organs, such as through the double or triple zip-tied anastomosis technique, it is essential to establish a seamless interface that reduces the likelihood of leakage or infection.
ii) In paediatric cardiothoracic surgery, the effectiveness of these methods leads to considerably improved scar formation and increased comfort for sensitive patient populations
iii) For facial structures, given the area's sensitivity and cosmetic considerations, though appropriate training is essential for clinicians.
iv) Temporary reduction and stabilization of an open mandibular fracture during initial emergency care, reducing pain and swelling [7].

FUTURE SCOPE:

A major focus for the future is the optimization of zip-tie designs and material properties. This includes developing materials compatible with diverse skin types, considering variations in thickness, elasticity, and sensitivity among individuals. Future advancements may incorporate adjustable tension systems featuring diverse material characteristics, enabling the force exerted on the skin to be customized for each individual, thus improving safety. Additionally, there is a significant focus on innovations related to biodegradable and antimicrobial materials. For instance, biodegradable polymers that naturally degrade could eliminate the need for removal and potential long-term complications. Investigations into materials such as albumin-based sutures and polycaprolactone infused with Nanosilver indicate a promising potential for increased biodegradability and enhanced antibacterial characteristics. Additionally, hypoallergenic materials and innovative coatings are being considered to minimize inflammatory responses, discomfort, and excessive scar tissue. The design will continue to evolve, becoming increasingly ergonomic and adaptable, which will facilitate easy application and modification in difficult anatomical areas, with the objective of creating designs that are adaptable for various surgical locations, ranging from intricate facial structures to abdominal and orthopedic procedures.

CONCLUSION:

As per the current investigation, demonstrated in the various research and review articles, highlights the efficacy, safety of zip-type closures, which emphasize their uses in various clinical scenarios and are expected to see expanded use in advanced surgical techniques in the future. Traditional methods require significant skill, time, and can lead to uneven results.

The zip-type closure provides accuracy, rapidity, uniformity, and a polished appearance with reduced effort. It not only simplifies the task but also opens up possibilities for more complex and delicate work, leading to better, faster, and more satisfying outcomes for both the patients and surgeons.

Ultimately, the objective is for surgical zip-type closures to evolve into a collection of specialized

closures, each tailored to meet distinct surgical requirements, which may include dissolving biodegradable variants as well as antimicrobial options for infection control. A contemporary toolkit for the future of surgical zip ties is centered on the development of a tailored collection of instruments, each crafted to precisely address the distinct requirements of different surgical operations. The main disadvantages of zipper devices are their ineffectiveness in high-tension areas where the wound undergoes constant movement (like joints) or experiences considerable stress, potentially jeopardizing the closure from coming undone, so focusing on this area could improve the access's ability to zip-type closure.

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