



# Rectified Pulley Suture for the synthesis of tensioned skin wounds

## *Sutura em Polia Retificada para síntese de feridas de pele tensionadas*

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### ■ ABSTRACT

**Introduction:** The synthesis of tensioned skin wounds is an area that has been the subject of studies for the development of suturing techniques that are capable of performing the primary closure of these wounds with tension relief, ensuring adequate healing, and avoiding complications such as dehiscence, edema, bleeding, and infection. **Method:** This research was a pilot study, being the first presentation of the Rectified Pulley Suture technique for the synthesis of tensioned skin wounds through prospective, double-blind monitoring of a series of cases of 8 patients randomly admitted to the surgical center of a high-complexity hospital in a medium-sized city. **Results:** Rectified Pulley Suture is a versatile technique suitable for dealing with tensioned skin wounds, since intraoperatively it was able to close, by first intention, lesions measuring up to 6.5 centimeters and in different tensioned regions without the need for the use of more extensive techniques, complex, such as flaps, grafts, Z-plasty, and secondary intention closure. Furthermore, post-operatively, there was a reduction in POSAS scores, indicating a satisfactory healing process for both observers and the patient. It is also essential to mention that the most feared outcome in the follow-up of patients with tension wounds undergoing primary closure - dehiscence - was completely avoided. **Conclusion:** The technique is simple, reliable, safe, and reproducible, with a short learning curve, so the Rectified Pulley Suture can be considered a new tool to be integrated into the surgical arsenal.

**Keywords:** Wound closure techniques; Surgical wound dehiscence; Cicatrix; Suture techniques; Surgical procedures, operative.

### ■ RESUMO

**Introdução:** A síntese de feridas de pele tensionadas é uma área que tem sido alvo de estudos para o desenvolvimento de técnicas de sutura que sejam capazes de realizar o fechamento primário dessas feridas com alívio de tensão, garantindo uma cicatrização adequada e evitando complicações como deiscência, edema, sangramento e infecção. **Método:** Esta pesquisa tratou-se de um estudo piloto, sendo a primeira apresentação da técnica de Sutura em Polia Retificada para síntese de feridas de pele tensionadas através do acompanhamento prospectivo, duplo-cego, de uma série de casos de 8 pacientes randomicamente admitidos no centro cirúrgico de um hospital de alta complexidade de uma cidade de médio porte. **Resultados:** A Sutura em Polia Retificada é uma técnica versátil e apta para lidar com feridas de pele tensionadas, uma vez que no intraoperatório conseguiu fechar por primeira intenção lesões de até 6,5 centímetros e de diferentes regiões tensionadas sem necessidade do uso de técnicas mais complexas, como retalhos, enxertos, zeta-plastia e fechamento por segunda intenção. Além disso, no pós-operatório, houve redução dos escores da POSAS, indicando um processo de cicatrização satisfatório tanto para os observadores quanto para o paciente. É imprescindível mencionar,

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também, que o desfecho mais temido no seguimento dos pacientes com feridas tensionadas submetidos a fechamento primário - a deiscência - foi completamente evitado. **Conclusão:** A técnica é simples, confiável, segura e reprodutível, com curta curva de aprendizagem, de forma que a Sutura em Polia Retificada pode ser considerada como uma nova ferramenta a ser integrada ao arsenal cirúrgico.

**Descritores:** Técnicas de fechamento de ferimentos; Deiscência da ferida operatória; Cicatriz; Técnicas de sutura; Procedimentos cirúrgicos operatórios.

## INTRODUCTION

Tensioned skin wounds are tissue continuity solutions resulting from extensive debridement or significant tissue loss, as occurs in the surgical excision of skin tumors or nevus, mainly in the scalp, chest, back, and extremities region<sup>1,2</sup>. The synthesis of these tension wounds is an area that has been the subject of studies for the development of suturing techniques that are capable of performing the primary closure of these wounds with tension relief, ensuring adequate healing and avoiding complications, such as dehiscence, edema, bleeding, and infection<sup>1</sup>.

Traditionally, “vertical mattress” (Donatti suture, or far-far-near-near) or “horizontal mattress” (U-shaped suture) sutures are used, both of which approximate the subcutaneous tissue and provide eversion of the edges, ensuring more adequate healing<sup>1</sup>. Furthermore, these sutures that involve the subcutaneous tissue have a lower incidence of incisional surgical site infection<sup>3</sup>. However, it is worth pointing out that both sutures can cause excessive tensile force at the edges of the wound, leading to tissue ischemia and a greater risk of dehiscence. Because of this, it is possible to apply these sutures only at the site of maximum wound tension, interspersing other discontinuous points in the rest of the wound<sup>4</sup>.

Despite being widely known and implemented, these traditional sutures have undergone adaptations that have brought new mechanical advantages for relieving tension when closing tensioned surgical wounds, such as the “pulley suture”<sup>5</sup> (pulley suture or “far-near-near-far”), in which its 4 insertion points act as 4 pulleys, reducing tension by 25% at each point<sup>6</sup>, which, in addition to relieving tension and facilitating the approximation of the wound edges, also presented other reported advantages, such as better hemostasis during the procedure and general reduction in time and cost to perform the suture<sup>6,7</sup>.

Aware of these benefits of pulley sutures for closing tensioned skin wounds, other authors described adaptations with the pulley principle, such as: “tandem pulley stitch”<sup>8</sup>; “pulley set-back dermal suture”<sup>9</sup>; “modified winch stitch suture”<sup>10</sup>; and “double-butterfly”<sup>11</sup>.

However, to improve pulley suturing and further prevent the risk of wound dehiscence, the vast majority of these techniques have become complex, difficult to handle and apply, often requiring innovative instruments for complete implementation. In fact, when tying the knots and finalizing these complex sutures that deal with such tension, other techniques for tying the knots were created, such as the “double loop-dermal suture”<sup>12</sup>; and the “loma-linda loop”<sup>13</sup>. Still others require different materials and two surgical stages, such as “elastic sutures”<sup>14,15</sup>.

Thus, analyzing the current scenario, the literature shows that there are other suturing possibilities with additional advantages when applying the pulley principle. Given the new complex possibilities, the authors propose a simpler adaptation of the “pulley suture”, with a small learning curve, which still uses the principle of pulleys to relieve tension, combined with subcutaneous insertions to reduce the risk of incisional infection of the surgical site, adequate coaptation of the edges to provide an aesthetic scar, and ease of tying the knots to optimize intraoperative time, called “Rectified Pulley Suture”, that is, an improvement on the “pulley suture”.

## OBJECTIVE

The authors, when analyzing the current panorama of suturing techniques already developed for tensioned skin wounds, used their theoretical-practical foundations to develop and improve a skin suture that uses the pulley principle, called Rectified Pulley Suture. This study aimed to describe the Rectified Pulley Suture and evaluate its versatility and applicability for closing tensioned skin wounds and, thus, integrating into the surgeon’s arsenal a new suturing technique that is easy to perform, fast, scientifically based, and safe, which in many cases can be an alternative to more complex techniques, such as other sutures and even flaps, grafts and Z-plasty.

## METHOD

This is an observational study of the results of a series of prospective cases, approved by the Ethics and Research Committee of UniCesumar (CAAE

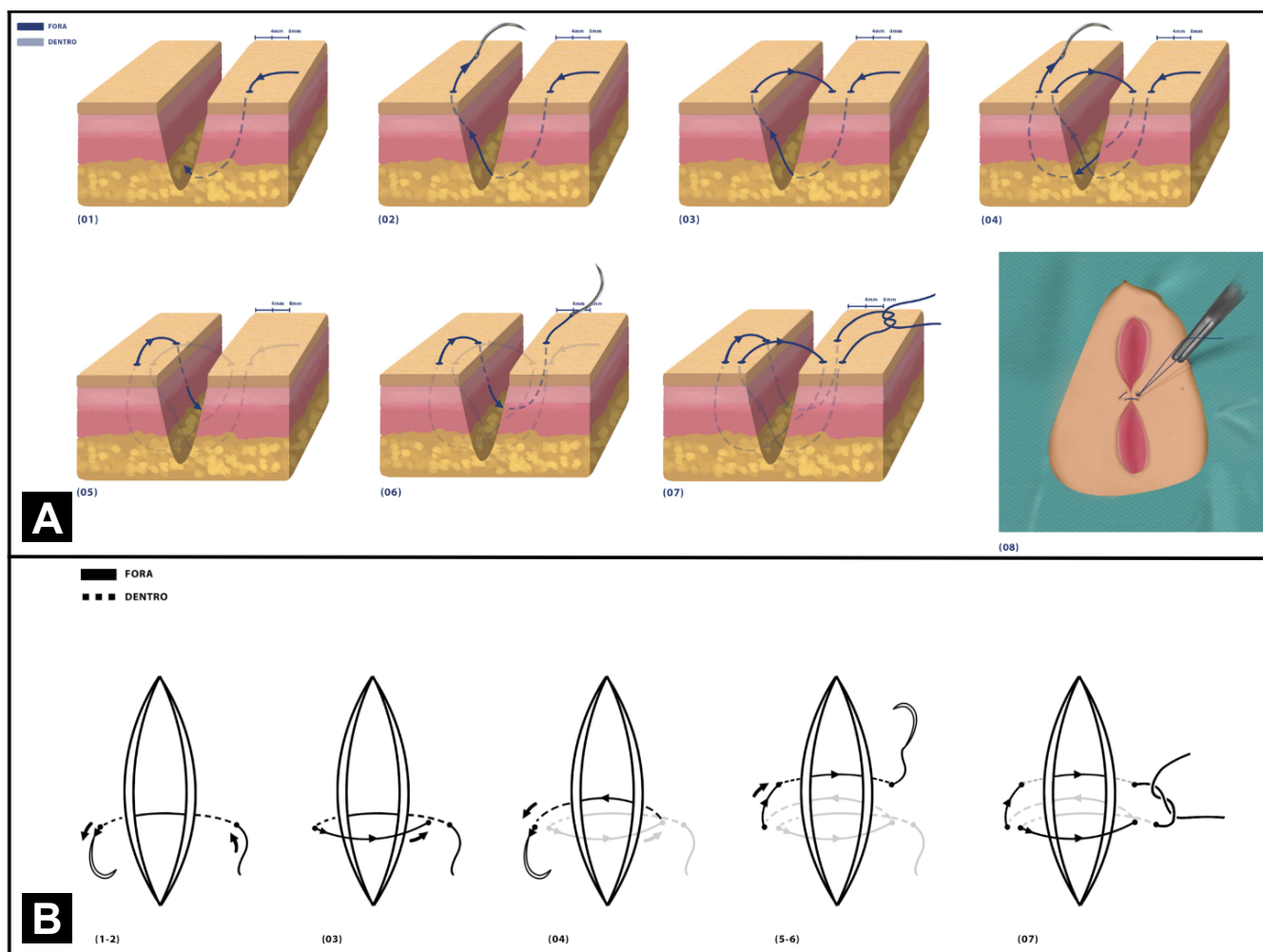
63832322.3.0000.5539), and carried out at the Surgical Center of the Oncology Department of Hospital Santa Rita, in Maringá-PR, upon declaration of authorization from the location.

The Rectified Pulley Suture technique consists of 7 steps, which can be seen in Figure 1: 1) the needle is inserted approximately 8 millimeters (mm) from the edge of the wound (“far”); 2) the needle is taken to the opposite side of the wound and inserted approximately 4mm from the contralateral edge (“near”); 3) the needle is again brought to the initial edge, but this time it is inserted 4mm from the edge (“near”); 4) to complete the pulley, the needle is inserted 8mm from the contralateral (“far” edge); 5) the needle is then inserted again into the contralateral edge and 4mm from the edge (“near”), however, this time in a line parallel to the already formed pulley; 6) still in this parallel line, the needle is inserted approximately 4mm into the edge of the beginning of the technique (“near”); 7) creation

of the double surgeon’s knot with the aid of a needle holder to complete the suture.

The addition of 2 new insertion points (steps 5 and 6, “near-near”) in a suture line parallel to the pulley construction line (steps 1, 2, 3, and 4; “far-near-near-far”), when compared to the “pulley suture”, facilitates the distribution of tension throughout the wound, improves the coaptation of the edges and also facilitates the creation of a double surgeon’s knot without the need for specific surgical instruments or the contribution of an auxiliary doctor ( since the “start” and “end” of the technique are located on the same edge of the wound).

Patients randomly admitted over the period from 02/17/2023 to 04/24/2023 were recruited considering the following inclusion criteria: 1) adults over 18 years old, of both sexes, of all ethnicities, literate and non-literate -literate, without socioeconomic distinction; 2) adults capable of understanding the benefits, risks and consequences of study participation and capable



**Figure 1.** Illustrations of the Rectified Pulley Suture. In A, Rectified Pulley Suture, step by step in colorful three-dimensional illustration. In B, an illustration of the technique is in the top view, black and white. Source: Authors, 2023.

of providing informed consent; 3) present skin wounds measuring 1-10 centimeters in areas of great tension, such as the back, chest, scalp, face, upper and lower limbs, capable of being subjected to primary closure.

Patients with keloids, hypertrophic scars, autoimmune or immunosuppressive diseases, or using corticosteroids, non-steroidal anti-inflammatory drugs, immunosuppressants, or who required other surgical techniques such as flaps, grafts, or Z-plasty were excluded. However, patients with poor nutritional status, smokers, alcoholics, or those with other non-infectious chronic diseases were not excluded from the study.

Those who met the inclusion criteria were invited to participate in the research and, upon signing the Informed Consent Form, underwent implementation of the Rectified Pulley Suture by a qualified surgeon, totaling 8 patients.

The technique was performed at the point of greatest tension in the wound (i.e., in the center), while the ends of the wound could be sutured with other discontinuous stitches, all of which used 3-0 monofilament nylon thread (Mononylon Ethilon; Ethicon), which is a monofilament thread, non-absorbable, versatile, strong, capable of reducing tissue traction and with a lower risk of developing postoperative infection when compared to multifilament threads, as it presents greater biostability<sup>16</sup>. Photographs of the tensioned wounds were recorded throughout the technique implementation procedure, its immediate and postoperative results, as documentation and demonstration of the suture. The wounds were measured with a surgical ruler considering their largest and smallest dimensions.

Postoperatively, all patients were instructed on daily wound care (cleaning and maintaining dressings, use of simple analgesics), and on the following restrictions: the use of healing ointments, immunosuppressants, and steroidal anti-inflammatories was not permitted, or corticosteroids; as well as it was not allowed to scratch the area or even remove the stitches early on your own, as the removal of stitches took place between 2-3 weeks, together with the reevaluation of the wound.

Then, to document the versatility and applicability of the Rectified Pulley Suture, the scarring process was assessed using the Patient and Observer Cicatricial Assessment Scale (POSAS) translated into Portuguese<sup>17</sup> on two occasions: the first between 15<sup>o</sup> to the 21<sup>st</sup> day after implementing the technique (along with the removal of stitches), and the second between the 60<sup>th</sup> to 90<sup>th</sup> day.

POSAS uses subjective parameters in an objective manner and is considered a reliable, viable, consistent, valid, and innovative scale that, in addition

to considering the observer's opinion, gives weight to the patient's opinion as an evaluator, having received the best evaluations in reviews<sup>18,19</sup>. POSAS includes two scales (patient and observer), shown in Figure 2, both of which contain 6 items that can be individually scored from 1 (scar similar to normal skin) to 10 (worst scar or sensation imaginable), whose final scores are each of the scales from the sum of the individual items ranges from 6 (reflecting normal skin) to 60 (worst imaginable scar).

Among the parameters evaluated on the observer scale are: vascularization, pigmentation, thickness, relief, malleability, and surface area. Among the items evaluated on the patient scale are: pain, itching, color, stiffness, thickness, and relief. Furthermore, both the observer and the patient can give a general opinion of the scar compared to normal skin, whose score also varies from 1 (same as normal skin) to 10 (worst imaginable scar). It is worth mentioning that the patient scale was filled out by the patients themselves with the help of a photograph when the wound could not be directly visualized, and non-literate patients received assistance with reading and recording. The observer scale was applied in a randomized, double-blind, and non-simultaneous manner<sup>17</sup>.

A patient identification questionnaire was also compiled regarding identification number (n), age, sex, ethnicity, origin, profession, monthly personal income, education, medications for continuous use and sporadic use, comorbidities, and lifestyle habits. Furthermore, in addition to the parameters of the observer's scale and the questionnaire applied, other parameters and outcomes were noted regarding their presence (yes or no) such as infection and dehiscence, and graded as crosses (1+/4+) such as bleeding and edema. Also, to complement the patient's scale, they were asked about cleaning and maintenance of dressings, handling the wound, changing eating patterns, developing new habits, and using medications post-operatively.

Data relating to POSAS were gathered, tabulated, and analyzed based on the Observer Total Score (OTS), Observer General Opinion Score (OOS), Patient Total Score (PTS), and Patient General Opinion Score (POS), based on the information collected in the patient identification questionnaire, to produce data compilation tables and descriptive analysis, to document the favorable and unfavorable outcomes of the suturing technique<sup>17</sup>.

## RESULTS

The sample consisted of 8 patients who underwent excision of skin tumors in different tension regions, both non-melanoma cancer and melanoma.

### POSAS Escala do paciente

The Patient and Observer Scar Assessment Scale - Portuguese version  
Escala de Avaliação Cicatricial Paciente/Observador - versão em Português

N. Identificação: \_\_\_\_\_ Data Avaliação: \_\_\_\_\_

1=não, nem um pouco sim, muito=10

1 2 3 4 5 6 7 8 9 10

HOUVE DOR NA CICATRIZ NAS ÚLTIMAS SEMANAS?  1  2  3  4  5  6  7  8  9  10

HOUVE COCEIRA NA CICATRIZ NAS ÚLTIMAS SEMANAS?  1  2  3  4  5  6  7  8  9  10

1=não, igual à pele normal sim, muito diferente=10

A COR DA CICATRIZ ESTÁ DIFERENTE DA COR DA SUA PELE NORMAL NESTE MOMENTO?  1  2  3  4  5  6  7  8  9  10

A RIGIDEZ DA CICATRIZ ESTÁ DIFERENTE DA SUA PELE NORMAL NESTE MOMENTO?  1  2  3  4  5  6  7  8  9  10

A ALTURA DA CICATRIZ ESTÁ DIFERENTE DA SUA PELE NORMAL NESTE MOMENTO?  1  2  3  4  5  6  7  8  9  10

A CICATRIZ ESTÁ MAIS IRREGULAR QUE SUA PELE NORMAL NESTE MOMENTO?  1  2  3  4  5  6  7  8  9  10

1=igual à pele normal muito diferente=10

QUAL SUA OPINIÃO GERAL DA CICATRIZ COMPARADA À PELE NORMAL?  1  2  3  4  5  6  7  8  9  10

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Fez a limpeza e manutenção adequada dos curativos? ( ) Não ( ) Sim \_\_\_\_\_

Coçou a ferida ou retirou as crostas da cicatriz? ( ) Não ( ) Sim \_\_\_\_\_

Mudou padrão alimentar? ( ) Não ( ) Sim, o que mudou? \_\_\_\_\_

Fez uso de medicação durante a recuperação? ( ) Não ( ) Sim, qual? \_\_\_\_\_

Desenvolveu novos hábitos após a cirurgia? ( ) Não ( ) Sim, qual? \_\_\_\_\_

### POSAS Escala do observador

The Patient and Observer Scar Assessment Scale - Portuguese version  
Escala de Avaliação Cicatricial Paciente/Observador - versão em Português

N. Identificação: \_\_\_\_\_ Sangramento: ( ) Não ( ) Sim: \_\_\_\_\_

Data Avaliação: \_\_\_\_\_ Infecção: ( ) Não ( ) Sim: \_\_\_\_\_

Dimensão da Ferida (cm): \_\_\_\_\_ Edema: ( ) Não ( ) Sim: \_\_\_\_\_

- Maior Extensão: \_\_\_\_\_ Deiscência: ( ) Não ( ) Sim: \_\_\_\_\_

- Menor Extensão: \_\_\_\_\_

Local da Lesão:

1=pele normal pior cicatriz imaginável=10

PARÂMETROS	1	2	3	4	5	6	7	8	9	10	CATEGORIAS
VASCULARIZAÇÃO	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	PÁLIDA   ROSADA   AVERMELHADA   VIOLÁCEA   MISTA
PIGMENTAÇÃO	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	HIPO   HIPER   MISTA
ESPESSURA	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	MAIS ESPESSA   MAIS FINA
RELEVO	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	MAIS   MENOS   MISTA
MALEABILIDADE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	ELÁSTICA   RÍGIDA   MISTA
ÁREA DA SUPERFÍCIE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	ALARGAMENTO   RETRAÇÃO   MISTA
OPINIÃO GERAL	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10										

Orientações  
A escala de observador da POSAS consiste em seis itens (vascularização, pigmentação, espessura, regularidade, maleabilidade e área da superfície). Todos os itens têm opções que variam de 1 ("igual à pele normal") a 10 ("pior cicatriz imaginável").  
A soma destes seis itens resulta no escore total da escala de observador da POSAS. Merações categoriais são adicionadas para cada item. Ainda, uma opinião geral é racionada em uma escala variando de 1 a 10.  
Todos os parâmetros devem ser preferencialmente comparados à pele normal ou a uma área anatómica comparável.

Notas explicativas dos itens:  
• **VASCULARIZAÇÃO** Presença de vasos no tecido cicatricial por medição de enchimento capilar após empalidecer com Pinúrgis. Na avaliação categorial, considere coloração predominante.  
• **PIGMENTAÇÃO** Coloração amarelada da cicatriz por pigmento melanínico; aplique o Pinúrgis na pele com pressão moderada para eliminar o efeito da vascularização.  
• **ESPESSURA** Distância média entre a borda subcutânea da derme e a superfície da cicatriz.  
• **RELEVO** A referência onde irregularidades de superfície se apresentam preferencialmente comparado com pele normal adjacente.  
• **MALEABILIDADE** Plasticidade da cicatriz testada por plegamento entre o polegar e o indicador.  
• **ÁREA DA SUPERFÍCIE** Área de superfície da cicatriz em relação à área da lesão original.

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Figure 2. Patient and Observer Scar Assessment Scale (POSAS).

Among them, there were 4 men and 4 women, all of white ethnicity, aged 52 to 76 years, with an average age of 65 years. Regarding the location of the wounds, they were all different, including the sternal, brachial, back of the hand, tibial, dorsal, scalp, and malar region of the face (different regions were chosen to demonstrate versatility). Regarding the size of the wounds, they ranged from 3.4 to 6.5cm in the largest diameter (average of 5.0cm) and from 1.4 to 5.0cm in the smallest diameter (average of 2.5cm). The complete demographic profile is listed in Table 1.

In the first assessment, concerning the observer scale, the OTS, calculated from the average between the scores of observers 1 and 2, ranged from 16.0 to 35.5 points (average of 22.5); the OOS, also calculated from the average of the observers' scores, ranged from 2.5 to 6.5 points (average of 4.0). Regarding the patient scale, the PTS ranged from 8.0 to 35.0 points, with an average of 21.6. The POS ranged from 1.0 to 8.0 points (average of 3.9). Regarding outcomes, no patient presented

dehiscence of the stitches; only two patients (4 and 7) had surgical site infections; four reported mild bleeding in the first postoperative days (1, 3, 5, and 7); and three presented edema (1, 4 and 7), two of which reported considerable edema (4 and 7). The individual scores and outcomes of the first assessment can be seen in Table 2.

In the second assessment, in relation to the observer's scale, the OTS ranged from 14.0 to 23.5 points (average of 17.4; reduction of 5.1 points or -9.4% in relation to the first meeting); the OOS ranged from 2.0 to 4.5 points (average of 3.3, reduction of 0.7 points or -7.8% in relation to the first assessment). In relation to the POSAS patient scale, the PTS ranged from 8.0 to 35.0 points, with an average of 15.8, and a reduction of 5.8 points or -10.7% in relation to the first encounter. The POS varied from 1.0 to 6.0 points (average of 3.0, reduction of 0.9 points or -9.9% in relation to the first assessment). Patients who presented any of the unfavorable outcomes in the first evaluation had complete resolution and no new complications. The

remaining patients also did not present new outcomes. The scores and individual outcomes of the second assessment can be seen in Table 3.

Photographic examples of the implementation of the Rectified Pulley Suture and the postoperative scar evolution are shown in Figures 3 to 10.

**Table 1.** Demographic profile of patients undergoing Rectified Pulley Suture.

n	Age	Sex	Ethnicity	Wound Location	Dimensions (cm)
1	55	Masculine	White	Malar Left	3.4 x 2.0
2	64	Feminine	White	Back Face Left Arm	6.5 x 5.0
3	52	Feminine	White	Right Medial Tibial Surface	5.8 x 2.0
4	73	Masculine	White	Left Back	6.0 x 2.5
5	63	Masculine	White	Posterior Left Parietal Scalp	4.0 x 1.4
6	64	Masculine	White	Sternal	6.0x 2.8
7	76	Feminine	White	Dorsal Face Right hand	4.2x 2.5
8	74	Feminine	White	Side Face Left arm	4.2x 1.6

Abbreviation: n=patient identification number in the study.

**Table 2.** First assessment of healing between 15 and 21 days after the intervention.

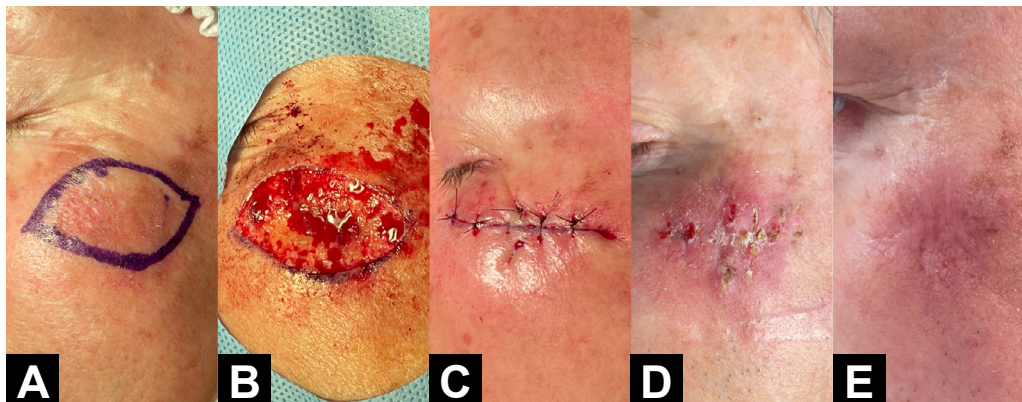
n	OTS			OOS			PTS	POS	S	I	E	D
	OTS1	OTS2	OTSm	OOS1	OOS2	OOSm						
1	21	22	21.5	4	3	3.5	14	3	1+	No	1+	No
2	18	18	18	3	3	3	16	3	0	No	0	No
3	34	37	35.5	7	6	6.5	32	8	2+	No	0	No
4	19	15	17	3	3	3	8	1	0	Yes	3+	No
5	13	19	16	2	3	2.5	18	2	1+	No	0	No
6	24	25	24.5	5	4	4.5	30	4	0	No	0	No
7	26	28	27	5	5	5	35	5	1+	Yes	3+	No
8	20	21	20.5	4	4	4	20	5	0	No	0	No

OTS1=Total Score of Observer 1; OTS2=Total Score of Observer 2; OTSm=Average of Total Observer Scores; OOS1=Observer 1's General Opinion Score; OOS2=Observer 2's General Opinion Score; OOS=Average of Observers' General Opinion Scores; PTS=Total Patient Score; POS=Overall Patient Opinion Score; S=Bleeding; I=Infection; E=Edema; D=Dehiscence.

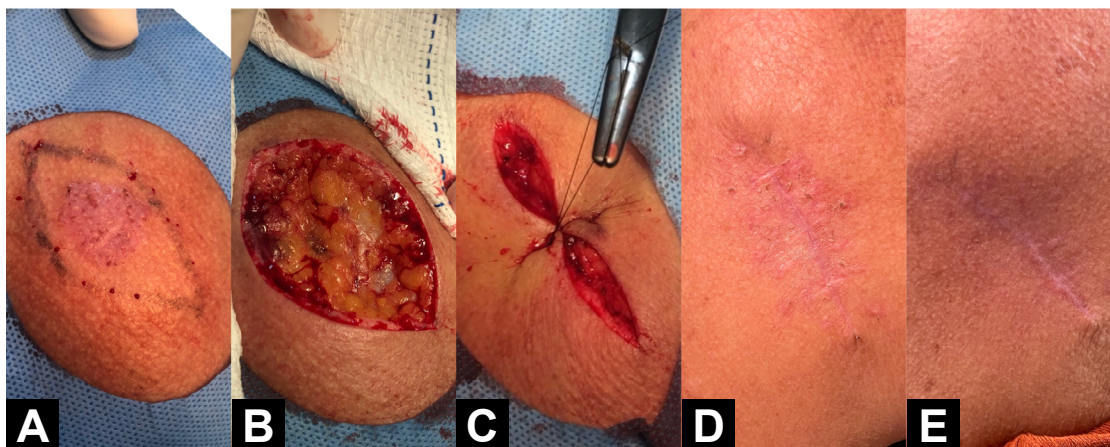
**Table 3.** Second evaluation of healing in the period of 60 to 90 days after the intervention.

n	OTS			OOS			PTS	POS	S	I	E	D
	OTS1	OTS2	OTSm	OOS1	OOS2	OOSm						
1	21	15	18	4	3	3.5	22	2	0	No	0	No
2	14	14	14	2	2	2	10	2	0	No	0	No
3	21	26	23.5	4	5	4.5	19	5	0	No	0	No
4	18	16	17	4	3	3.5	8	1	0	No	0	No
5	12	15	13.5	2	3	3.5	8	2	0	No	0	No
6	18	14	16	3	2	2.5	12	2	0	No	0	No
7	21	18	19.5	4	3	3.5	12	4	0	No	0	No
8	17	19	18	4	3	3.5	35	6	0	No	0	No

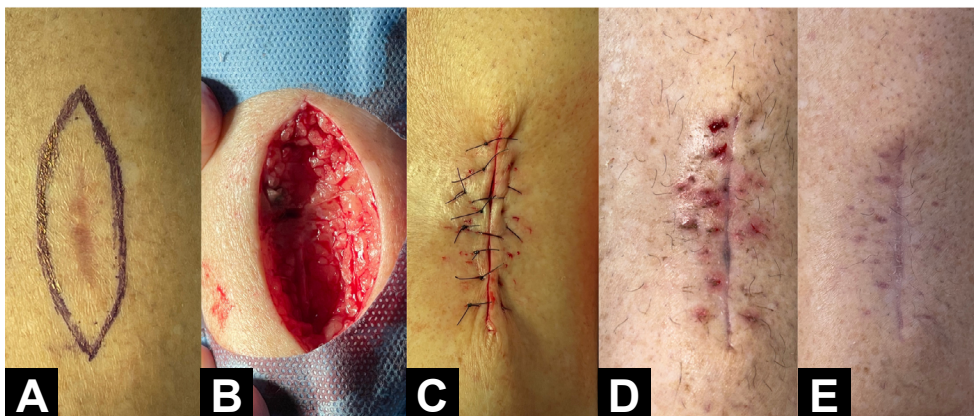
OTS1=Total Score of Observer 1; OTS2=Total Score of Observer 2; OTSm=Average of Total Observer Scores; OOS1=Observer 1's General Opinion Score; OOS2=Observer 2's General Opinion Score; OOS=Average of Observers' General Opinion Scores; PTS=Total Patient Score; POS=Overall Patient Opinion Score; S=Bleeding; I=Infection; E=Edema; D=Dehiscence.



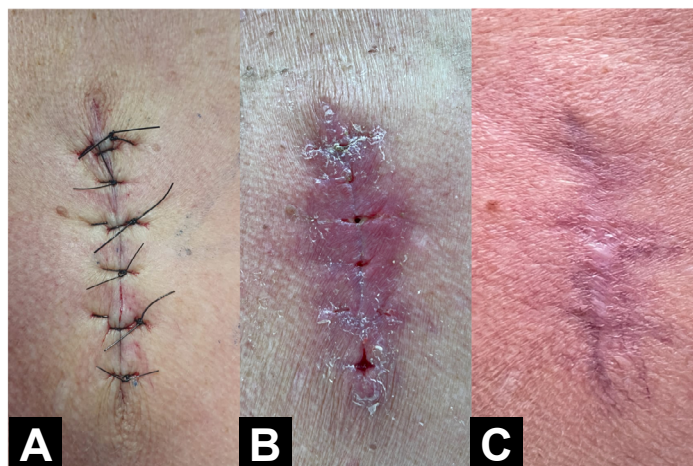
**Figure 3.** Patient 1, lesion in the left malar region measuring 3.4 x 2.0cm. AB. Day 0, surgical appointment for skin excision and surgical wound after excision. C. Day 0, immediate result of applying the Rectified Pulley Suture in the center and simple stitches at the ends. D. Day 18, scar from the first assessment after stitch removal. E. Day 61, scar on second evaluation. Source: Authors' photo bank, 2023.



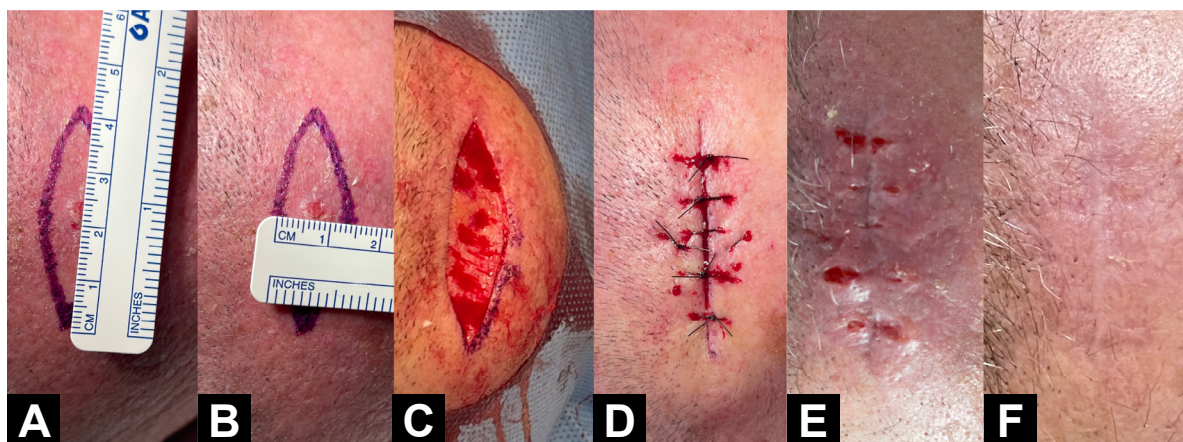
**Figure 4.** Patient 2, lesion on the posterior surface of the left arm measuring 6.5 x 5.0cm. AB. Day 0, surgical appointment for skin excision and surgical wound after excision. C. Day 0, application of the Rectified Pulley Suture in the center of the scar. D. Day 18, scar in the first assessment. E. Day 60, scar in the second evaluation, with increased relief at the ends and deepening in the center. Source: Authors' photo bank, 2023.



**Figure 5.** Patient 3, lesion on the medial tibial surface of the right leg measuring 5.8 x 2.0cm. In A, surgical marking for excision of recurrent melanoma in the left tibial region. In B, extensive surgical wound with little tissue for approximation. In C, creation of 2 Rectified Pulley Sutures in the center of the wound interspersed with Donatti stitches. In D, scar in the first evaluation after 18 days together with the removal of the stitches. In E, scar in the second evaluation 67 days after surgery. Source: Authors' photo bank, 2023.



**Figure 6.** Patient 4, lesion in the left dorsal region measuring 6.0 x 2.5cm. A. Day 0, creation of 3 Rectified Pulley Sutures interspersed with simple stitches. B. Day 16, hyperemic scar in the first assessment after removing the stitches. C. Day 60, scar similar to normal skin in the second evaluation. Source: Authors' photo bank, 2023.

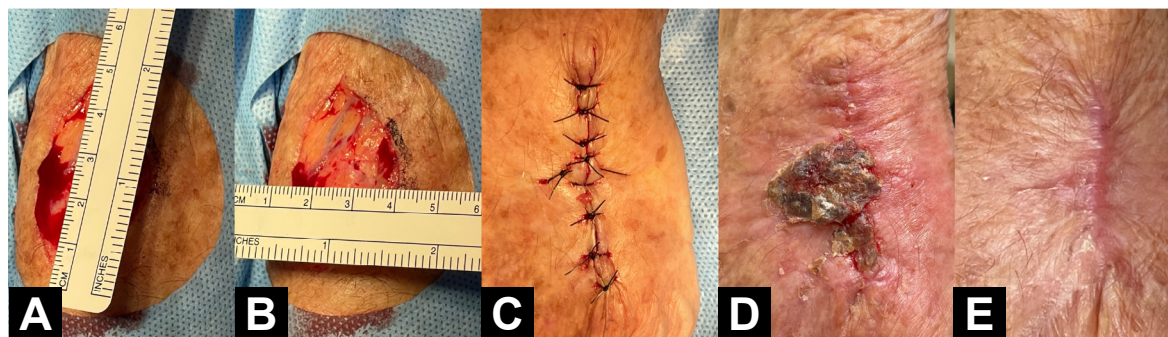


**Figure 7.** Patient 5, lesion in the left posterior region of the parietal scalp measuring 4.0 x 1.4cm. AB. Day 0, measurement of wound diameters with a surgical ruler. C. Day 0, surgical wound on scalp after excision of skin tumor. D. Day 0, application of a Rectified Pulley Suture in the center of the wound interspersed with simple stitches. E. Day 18, scar from the first assessment. F. Day 60, scar similar to normal skin in the second evaluation. Source: Authors' photo bank, 2023.



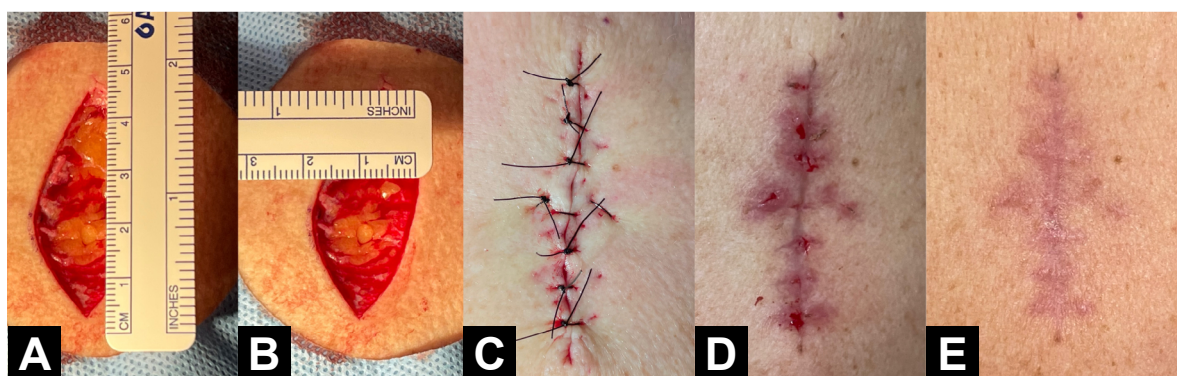
**Figure 8.** Patient 6, lesion in the sternal region measuring 6.0 x 2.8cm. AB. Day 0, surgical marking and delimitation of the skin removal area with a surgical ruler. C. Operative wound in the sternal region. D. Day 0, application of the Rectified Pulley Suture in the center of the wound, associated with simple stitches. E. Day 19, scar in the first assessment, with increased vascularity, hyperpigmentation, and relief irregularity. F. Day 61, scar similar to normal skin in the second evaluation. Source: Authors' photo bank, 2023.





**Figure 9.** Patient 7, lesion on the dorsal surface of the right hand measuring 4.2 x 2.5cm. In A and B, measurement of wound diameters with a surgical ruler. In C, application of the Rectified Pulley Suture in the center of the wound associated with simple stitches. In D, scar in the first evaluation after 15 days, together with crust formation due to infection, which even increasing tension did not promote suture dehiscence. In E, scar with slight retraction of surface area in the second evaluation after 87 days.

Source: Authors' photo bank, 2023.



**Figure 10.** Patient 8, lesion on the lateral side of the left arm measuring 4.2 x 1.6cm. AB. Day 0, Measurement of wound diameters with a surgical ruler. C. Day 0, application of the Rectified Pulley Suture in the center of the wound associated with simple stitches. D. Day 15, scar in the first evaluation after removing the stitches. E. Day 87, scar with slight surface area retraction in the second evaluation.

Source: Authors' photo bank, 2023.

## DISCUSSION

Although the research has limitations, such as short time for sample selection and monitoring, small sample size, impossibility of microscopic analysis of healing, lack of control group, impossibility of comparative analysis of the technique with other threads or in relation to other suturing techniques in the same study, it fulfilled its objective of presenting the technique and demonstrating its versatility and applicability in different contexts of resolving tension skin wounds.

This statement can be validated when considering the positive evolution of the scores, in which the reduction in the average score of all scores in the second evaluation (Table 3) in relation to the first (Table 2) demonstrates improvement in the healing process and suture suitability in Rectified Pulley, taking into account the analysis of observers and the patient, since the values closer to 1, the closer they are to normal skin and the best outcome imaginable.

Observers noted that the technique is simple, reliable, safe, and reproducible, with a short learning curve, so the Rectified Pulley Suture can be considered a new tool to be integrated into the arsenal of medical students, general practitioners, and surgeons. specialists, since techniques such as “pulley set-back dermal suture”<sup>9</sup>, “double-butterfly”<sup>11</sup>, “double loop-dermal suture”<sup>12</sup> and the “loma-linda loop”<sup>13</sup> have proven to be difficult to apply and have a long learning curve.

These results and observations regarding the Rectified Pulley Suture were consistent with the results of Kannan et al.<sup>7</sup>, who demonstrated a mechanical advantage of tension relief, ease of approximation of the wound edges, better hemostasis during the procedure, general reduction in time and the cost of creating the technique and reducing POSAS scores throughout the healing process using a suture with the pulley principle. Furthermore, it was noticed that the more pulleys were inserted, the greater the tension relief throughout the wound, further increasing the mechanical advantage

for wounds with little tissue to approach the edges, something that was also noted in patients 3 and 4<sup>7,8,10</sup>.

Furthermore, it is necessary to pay attention to local and general factors that negatively interfere with the healing process, and which can predispose to the main complications: bleeding, edema, infection, and dehiscence. Local factors are related to the condition of the wound and how it is treated surgically. General factors, on the other hand, are related to the patient's clinical conditions<sup>20-22</sup>.

In line with this, the infection observed in patient 4 can be, at least in part, justified by the smoking habit, which negatively influences the healing process through vasoconstriction, tissue ischemia, reduced inflammatory response, impaired bactericidal mechanisms, and alteration of the metabolism of collagen, increasing the likelihood of dehiscence and surgical site infection<sup>23,24</sup>.

Furthermore, the occurrence of edema associated with infection reinforces that the Rectified Pulley Suture was able to handle tension beyond that expected intraoperatively. In the case of patient 7, there was a greater risk of infection and dehiscence, since the surgical wound had distant edges, which did not follow Kraissl's skin tension lines<sup>25</sup> and, even with tissue flaccidity, contained little tissue for approximation. Furthermore, the hand is a region of great exposure and mobility which, combined with incorrect wound hygiene and inadequate maintenance of dressings reported by the patient and companion, resulted in infection with crusted formation. Even with this adverse outcome, the Rectified Pulley Suture distributed the tension and contributed to adequate healing<sup>2</sup>.

In general, the evolution of the scores of all patients shows that the suture is capable of promoting significant improvement in wounds in different regions and patients of different sexes, ages, and comorbidities. Furthermore, it provided additional advantages for those who, for some reason, did not have the same care with sutures, dressings, or health conditions.

## CONCLUSION

The Rectified Pulley Suture is a versatile technique, with the ability to deal with tensioned skin wounds, since intraoperatively it was able to nearby first intention lesions with dimensions of up to 6.5cm in the largest diameter and in different tensioned regions without the need for use of more complex techniques, such as flaps, grafts, Z-plasty, and secondary intention closure. Furthermore, post-operatively, there was a reduction in POSAS scores, which indicates a satisfactory healing process and good evolution for both observers and the patient.

It is also essential to mention that the most feared outcome in the follow-up of patients with tension wounds undergoing primary closure - dehiscence - was completely avoided in our sample, even though other outcomes that further increase the risk of dehiscence were present, such as infection, edema, and bleeding. The possibility of dealing with these complications and remaining intact is more relevant than their absence, which suggests the Rectified Pulley Suture as a safe technique in the face of the adverse outcomes of tensioned skin wounds.

## COLLABORATIONS

- MFT** Analysis and/or data interpretation, Conception and design study, Investigation, Visualization, Writing - Original Draft Preparation.
- JPGG** Analysis and/or data interpretation, Conception and design study, Investigation, Visualization, Writing - Original Draft Preparation.
- VA** Methodology, Project Administration, Writing - Review & Editing.
- IR** Conceptualization, Realization of operations and/or trials, Resources.

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