ORIGINAL ARTICLE

REVISTA ENFERMAGEM ATUAL IN DERME

BACTERIAL CELLULOSE REGENERATIVE DRESSING FOR TUMOR RESECTION WOUNDS

VENDAJE REGENERATIVO DE CELULOSA BACTERIANA PARA LESIONES POR RESECCIÓN TUMORAL

CURATIVO REGENERATIVO DE CELULOSE BACTERIANA PARA LESÕES POR RESSECÇÃO TUMORAL

[1]Kelly Monteiro dos Santos
[2]Layla Carvalho Mahnke
[3]Murielly Maximo Arcoverde
[4]José Lamartine de Andrade Aguiar
[5]Flávia Cristina Morone Pinto

[1]Universidade Federal de Pernambuco, Recife, Brazil. ORCID: https://orcid.org/0000-0001-8436-102X
[2]Universidade Federal de Pernambuco, Recife, Brazil. ORCID: https://orcid.org/0000-0001-8758-0877
[3]Universidade de Pernambuco, Nazaré da Mata, Brazil. ORCID: https://orcid.org/0009-0003-9020-2166
[4]Universidade Federal de Pernambuco, Recife, Brazil. ORCID: https://orcid.org/0000-0002-1206-5368
[5]POLISA Biopolimeros para a Saúde Ltda, Carpina, Brazil. ORCID: https://orcid.org/0000-0001-9196-7687

Autor Correspondente
Kelly Monteiro dos Santos
Rua Dona Benvinda de Farias, 562, Recife, Pernambuco, Brazil. CEP: 51020140. E-mail: kellymonteiro.ufpe@gmail.com fone: +55 (81) 99778-2546

Submission: 30-09-2024
Approval: 29-01-2025

ABSTRACT

Introduction: Wound management remains a challenge in the healthcare field. Although there is a variety of materials available on the market, wound dressings need to be changed regularly, which can lead to debridement and pain during dressing removal. Surgeries for resection of non-melanoma skin tumors often result in complex and extensive wounds, which require treatment with appropriate dressings, preferably low-cost and that allow efficient healing. Dressings composed of biomaterials such as bacterial cellulose (BC) have been used for this purpose because they are non-toxic, biocompatible, flexible, naturally adherent and transparent materials, which allows the healing process to be monitored without removing them. **Objective:** This study was developed to evaluate the response of surgical wounds resulting from tumor resection to treatment using PolyTissue®, a BC dressing obtained through the biotechnological conversion of sugarcane molasses. **Methodology**: This was a prospective study based on a case series involving 14 adult patients (15 lesions). Wound evaluation was performed using the MEASURE methodology, along with clinical discussions among healthcare professionals (triangulation). Wounds images were recorded using the digital app imitoMeasure®, and statistical analyses were conducted using SPSS software. **Results**: The participants (14) had a mean age of 64.4±8.2 years, with the majority being male (78.6%). The predominant location of the evaluated lesions (15) was the right lower limb (40.0%, p=0.047). A reduction in the measurements of the lesiones area, circumference, width, and length was observed in the final clinical evaluation (p<0.05), along with the absence of exudate in 13 of the 15 lesions evaluated (86.7%). The average healing time was 68 days. No participant reported pain during the study. **Conclusion**: The BC dressing (PolyTissue®) can aid in the healing of wounds resulting from the resection of non-melanoma skin tumors and provides comfort to patients, in addition to being low-cost.
Keywords: Bacterial Cellulose; Biopolymer; Sugarcane; Cancer; Healing; Surgical Wound.

RESUMO

Introdução: O manejo das feridas continua sendo um desafio na área da saúde, embora, exista uma variedade de materiais disponíveis no mercado, os curativos precisam ser trocados regularmente, promovendo desbridamento e dor durante sua remoção. Cirurgias para ressecção de tumores de pele do tipo não melanoma frequentemente resultam em feridas complexas e extensa, que exigem tratamento com curativos adequados, preferencialmente de baixo custo e que possibilitem uma cicatrização eficiente. Curativos compostos de biomateriais como celulose bacteriana (CB) vem sendo utilizado para esta finalidade por ser um material atóxico, biocompatível, flexível, de aderência natural e transparente, o que permite acompanhar o processo cicatricial sem sua remoção. **Objetivo:** Este estudo foi desenvolvido para avaliar a resposta de feridas cirúrgicas decorrentes de ressecção tumoral ao tratamento utilizando o PolyTissue®, curativo de CB obtido através da conversão biotecnológica do melaço de cana-de-açúcar. **Metodologia:** Trata-se de um estudo prospectivo a partir de uma série de casos, incluindo 14 pacientes adultos (15 lesões). A avaliação das feridas foi realizada através da metodologia MEASURE incluindo também discussões clínicas entre profissionais da área (triangulação). Foram realizados registros das feridas usando o aplicativo digital imitoMeasure® e as análises estatísticas foram conduzidas pelo software SPSS. **Resultados:** Os participantes (14) tinham idade média de 64,4±8,2 anos, sendo a maioria homens (78,6%). A localização predominante das lesões avaliadas (15) foi no membro inferior direito (40,0%, p=0,047). Observou-se redução das medidas de área, circunferência, largura e comprimento das lesões na última avaliação clínica (p<0,05) e ausência de exsudato em 13 das 15 lesões avaliadas (86,7%). O tempo médio de cicatrização foi 68 dias. Nenhum participante referiu dor durante o estudo. **Conclusão:** Conclui-se que, o curativo de CB (PolyTissue®) pode auxiliar na cicatrização de feridas decorrentes de ressecção tumoral de câncer de pele do tipo não melanoma e proporciona conforto aos pacientes, além de ser de baixo custo.
Palavras-chave: Celulose Bacteriana; Biopolímero; Cana-de-Açúcar; Câncer; Cicatrização; Ferida Cirúrgica.

RESUMEN

Introducción: El manejo de heridas sigue siendo un desafío en el campo de la salud, aunque hay una variedad de materiales disponibles en el mercado, los apósitos deben cambiarse periódicamente, lo que promueve el desbridamiento y el dolor durante su extracción. Las cirugías de resecado de tumores cutáneos no melanomas suelen dar lugar a heridas complejas y extensas, que requieren tratamiento con apósitos adecuados, preferiblemente de bajo coste y que permitan una cicatrización eficiente. Para este fin se han utilizado apósitos compuestos por biomateriales como la celulosa bacteriana (CB) por ser materiales atóxicos, biocompatibles, flexibles, naturalmente adherentes y transparentes, lo que permite monitorear el proceso de cicatrización sin necesidad de retirarlos. **Objetivo:** Este estudio fue desarrollado para evaluar la respuesta de las heridas quirúrgicas resultantes de la resección tumoral al tratamiento con PolyTissue®, un apósito de CB obtenido a través de la conversión biotecnológica de melaza de caña de azúcar. **Metodología**: Se trata de un estudio prospectivo basado en una serie de casos que incluyó a 14 pacientes adultos (15 lesiones). La evaluación de las heridas se realizó mediante la metodología MEASURE, que también incluyó discusiones clínicas entre profesionales de la salud (triangulación). Se registraron las heridas utilizando la aplicación digital imitoMeasure® y los análisis estadísticos se realizaron con el software SPSS. **Resultados**: Los participantes (14) tenían una edad media de 64,4±8,2 años, siendo la mayoría hombres (78,6%). La localización predominante de las lesiones evaluadas (15) fue en el miembro inferior derecho (40,0%, p=0,047). Se observó una reducción en las medidas de área, circunferencia, ancho y largo de las lesiones en la última evaluación clínica (p<0,05), y la ausencia de exudado en 13 de las 15 lesiones evaluadas (86,7%). El tiempo promedio de cicatrización fue de 68 días. Ningún participante informó dolor durante el estudio. **Conclusión**: Se concluye que el vendaje de CB(PolyTissue®) puede ayudar en la cicatrización de heridas resultantes de la resección de tumores de cáncer de piel no melanoma, proporcionando comodidad a los pacientes, además de ser de bajo costo.
Palabras clave: Celulosa Bacteriana; Biopolímeros; Caña de Azúcar; Cáncer, Cicatrización de Heridas; Herida Quirúrgica.

REVISTA ENFERMAGEM ATUAL IN DERME

INTRODUCTION

The wound healing process involves a number of factors such as time, risk of infection, tissue remodeling and pain management, which pose a challenge to healthcare professionals [1]. Therefore, the search for new and more effective treatments that prevent infections, in addition to helping the healing process, has increased in recent years [2].

When it comes to surgical wounds resulting from tumor resection, an even greater challenge is observed, as they generally present a slow healing process due to tissue loss and a high risk of infections and dehiscence. [3,4].

These wounds require smart dressings capable of inducing and/or leading to tissue remodeling, stimulating granulation, reducing the amount of exudate and promoting patient comfort [5]. Delayed healing can also cause psychological harm to the patient, high image disturbance, as well as social and economic losses [6].

Currently, there is a wide variety of materials available on the market, coverings called special dressings, to accelerate wound healing, reduce changes and reduce the pain generated by the dressing renewal process [7], however they are expensive, and therefore are not available in the Brazilian National Health System or are difficult for some patients to acquire [8].

Wound dressings are mainly developed from natural or synthetic polymers. Synthetic polymers include polyvinylpyrrolidone (PVP), poly(ethylene oxide) (PEO), polyethylene glycol (PEG), among others. However, some materials used have limitations such as reduced antimicrobial effect, poor mechanical performance, and inability to provide adequate moisture to accelerate the wound healing process [9].

Natural polymers that are commonly used include chitosan, cellulose, fibrin, elastin, hyaluronic acid, dextran, alginate, collagen, and gelatin (10). These polymers have properties suitable for wound management, such as high biocompatibility, low toxicity, biodegradability, immediate availability, and low immunogenicity. They are generally referred to as biopolymers. They tend to interact more harmoniously with tissues and cells, reducing the rejection probability, inflammation, or other adverse responses by the body, and are easily degraded by natural biological processes, meaning that after use, they break down into biologically inert components [11, 12].

Natural biopolymers are obtained from renewable sources such as plants, algae, animals and microorganisms, contributing to reducing dependence on finite resources and minimizing the environmental impact associated with the extraction and processing of non-renewable primary materials [12, 13]. They are usually collected as residual by-products at manufacturing scale, where they would likely be discarded, resulting in a good cost-benefit ratio [12, 14].

The Bacterial Cellulose (BC) dressing is a biopolymer obtained through biotechnological synthesis using sugarcane molasses in this work [12]. This product is non-toxic, biocompatible and

REVISTA ENFERMAGEM ATUAL IN DERME

has the characteristics of being transparent, flexible and with good adhesion to the wound bed [12, 13]. Because the transparent characteristic, is possible observe the healing process without remove it. The dressing adheres naturally to the wound bed (self-adherent) and gradually detaches as the tissue heals. The dressing used in this study, PolyTissue® produced by POLISA®, has already been tested in experimental research protocols and is being used in different clinical protocols in the health area, with satisfactory results for the treatment of surgical, traumatic, chronic (venous ulcers) and burn wounds. [14-29].

BC meets the recommendations of the United States Food and Drug Administration (FDA), the US agency that regulates drugs and food, which defines that a biomaterial to be used in the health area must be biocompatible and not be toxic, carcinogenic, antigenic or mutagenic, and must not interfere with the healing of damaged tissues [30,31]. Additionally, it can be manufactured on a large scale, can be sterilized, stable during implantation, non-corrosive, and non-degradable [32-34]. It also complies with the regulations of the Brazilian Health Regulatory Agency (ANVISA) and qualifying as class I (RDC 185/2001) [35], Rule 4, which refers to all non-invasive medical products that come into contact with damaged skin, are intended to be used as a mechanical barrier, for compression or for absorption of exudates.

METHODS

Study Design

This is a prospective study including a series of cases carried out during the period from March 2021 to April 2022, with patients referred by the Oncological Surgery Outpatient Clinic of the Pernambuco Cancer Hospital (PCH), Stomatherapy Outpatient Service for monitoring of the surgical wound.

Eligibility Criteria

All patients who participated in the study were ≥ 18 years-old, both sexes, with a histopathologically confirmed diagnosis of cancer, presenting surgical wounds resulting from tumor resection and without signs of infection. Patients who presented any sign of hypersensitivity to the dressing components, infected or cavitary wounds, pregnant or in the postpartum period were not included in the study.

Casuistry and Data Collection

Individual consultations were held in a private, air-conditioned and noise-free environment, explaining the study, risks and benefits to the patients. After listening carefully to the instructions and without any doubts, the Informed Consent Form (ICF) was signed, in accordance with resolution 466/2012 of the Brazilian National Health Council, the Declaration of Helsinki and the Nuremberg Code for human experimentation. The protocol was approved by the Research Ethics Committee of the Federal University of Pernambuco – Health Sciences Center with the CAAE number: 23402513.9.0000.5208 and of the PCH with CAAE number: 23402513.9.3002.5205.

A total of twenty-three patients were invited to participate in the study, of which eight

REVISTA ENFERMAGEM ATUAL IN DERME

were excluded because they didn't comply with the eligibility criteria mentioned above (35%) (see methodology: eligibility criteria) or refused to participate in the study, therefore, the sample studied was made up of fourteen participants and fifteen lesions.

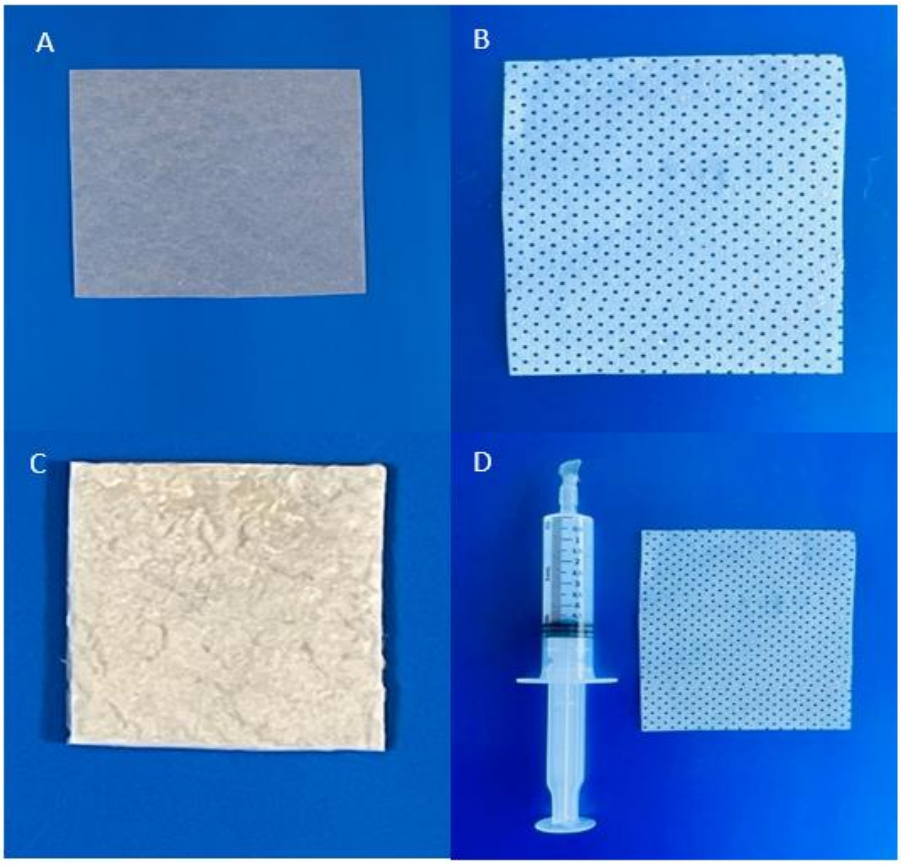
All participants were monitored at the PCH Stomatherapy Outpatient Clinic in weekly visits in the first two weeks to check the participant's adherence to the study and to evaluate the wound in relation to the proposed treatment with BC dressing. After this period, monitoring became biweekly for a maximum of 120 days (D120). Clinical evaluation, including replacement and adjustment of the primary dressing prescription (BC dressing) as needed, was conducted from the first month (D0), after thirty days (D30), sixty days (D60), ninety days (D90) and/or at most 120 days (D120), with a window of ± three days.

Bacterial Cellulose (BC) Dressing

BC dressings (PolyTissue®) were produced and supplied by Polisa® Biopolymers for Health Ltd., a company dedicated to research, development, technological innovation, production and marketing of sugarcane biopolymers (a start-up within the Incubatec of the Federal Rural University of Pernambuco). The BC for dressing is obtained via biotechnology process from sugar cane molasses diluted in water without any additives [12]. The BC obtained is treated and purified, resulting in a pure, crystalline product made up of micro and nano cellulose fibrils intertwined with each other, with a fine texture and uniform structure [12]. BC film has viscoelastic properties and remains stable when packages in a BagClean® or surgical grade®, stored at temperatures of 8-35°C [12]. BC is a very pure product, does not induce an immunological response, is biocompatible and non-toxic, with a wide range of clinical applications [10,12,30,36,37].

Figure 1 - Presentations of BC dressing. Compact film (A); Perforated film (B); Sponge (C); Hydrogel in the syringe and Perforated film (D).

REVISTA ENFERMAGEM ATUAL IN DERME



Source: Images provided by the company POLISA® Biopolymers for Health LTD.

The dressing used, PolyTissue® (Figure 1), acts as a mechanical barrier, protecting the wound and surrounded skin, facilitating the healing process [12,14,32,38]. The physical-chemical product characteristics allow the natural moisture of the tissues to be maintained, promoting tissue regeneration, epithelialization, and reducing healing time [12,23,31]. The PolyTissue® dressings were used in different sizes (5.0 X 5.0 cm; 6.0 X 7.0 cm; 10 X 16 cm) and, when necessary, were customized to adapt more precisely to the wounds.

Technical Procedures

All participants included underwent wound cleaning with 0.9% saline solution, followed by drying using sterile gauze to reduce moisture. Next, the wound was clinically assessed and the primary PolyTissue® dressing was directly applied. The dressing was kept moist with saline solution to facilitate handling, increase flexibility and better accommodate wound irregularities. The dressings were finished with gauze and wrapped with bandages. PolyTissue® dressing tends to naturally detach from the injured site after healing, which usually occurs in less than 30 days. In wounds where the healing time exceeded 30 days, the dressings were removed by the researcher for detailed evaluation of the wound and to respect the 30-day period of permanence recommended in the protocol.

Participants were instructed to only remove the secondary dressing, when performing their personal routine hygiene during the bath. They were also instructed to clean the

REVISTA ENFERMAGEM ATUAL IN DERME

primary BC dressing, removing excess moisture with sterile gauze and covering the primary dressing with a new secondary dressing.

Data Analysis

The wound assessment was performed using the MEASURE methodology (39), clinical discussions between an oncology nurse and a stoma care nurse (triangulation). images were captured by the imitoMeasure® digital application, which provided circumference, length and width dimensions in cm and the wound area in cm², and from digital photographic records with a cell phone camera. All lesions were photographed with the same camera on the iPhone® 12 Pro Max mobile device at a fixed distance.

The MEASURE system provides an overview of the principles and practices of chronic wound assessment. This system includes the evaluation of the wound in relation to size, width, length, depth, area, exudate (quantity and quality), pain, type of edge, detachment (absent or present) and the appearance of the wound, with the description of the inspection, type of tissue involved and coloration.

The imitoMeasure® application is an FDA-approved digital method developed for healthcare professionals to calculate wound dimensions (length, width, area and circumference) through a visual map obtained from photographic records made by a cell phone and which also allows electronic recording [40]. The application was used in digital image mode with manual calibration.

To ensure data accuracy, a photograph of the wound must be recorded with a ruler next to it to serve as a size reference, i.e. calibration. The edges of the wound are then outlined in the image and the dimensions are calculated in this way [41]. In this study, wounds were classified by size. A small wound was considered when the total wound area was ≤ 10 cm². A medium wound was considered when the area was between > 10 cm² and ≤ 50 cm², and a large wound was considered when the area was greater than > 50 cm².² [42].

Comparisons between categorical variables were performed using the Chi-square test or Fisher's exact test (when applicable), while Kruskal-Wallis and Mann-Whitney tests were used for the nonparametric data. For continuous variables test with paired samples, was used the Friedman test with the *pairwise* Wilcoxon Signed Ranks as *post-hoc* analysis. For the tests of categorical variables with paired samples, the marginal homogeneity test was used. All p-values were adjusted for both sides with a significance level of 0.05. When necessary, the Bonferroni correction was applied for multiple hypothesis comparisons. When necessary, the odds ratio (OR) and 95% confidence interval (95% CI) were considered. The analyses were performed using the SPSS (Statistical Package for Social Sciences) Statistics 19.0 software (IBM corporation).

The sociodemographic, clinical and oncological characteristics of the patients were detailed descriptively.

RESULTS

REVISTA ENFERMAGEM ATUAL IN DERME

Sociodemographic Data

Among the fourteen participants evaluated, the average age was 64.4±8.2 years, with eleven being male (78.6%). Six patients declared themselves to be brown (42.9%), nine were married (64.3%), nine lived in the metropolitan region (64.3%), six had secondary education (42.9%) and seven were retired (50.0%). There was no statistical difference between the variables analyzed ($p > 0.05$).

Oncological Data and Healing Outcomes

The histological lesions data obtained in this study indicated that the majority of patients had squamous cell carcinoma (73%) and in smaller proportions having basal cell carcinoma (13.3%), epidermoid carcinoma (6.7%) and infiltrating ductal carcinoma (6.7%). When analyzing the histological type of lesions with the healing outcome, no statistical difference was observed ($p > 0.05$). Concerning the areas of the body affected by lesions, one patient had a lesion on the breast (6.7%), two on the right upper limb (13.3%), four on the left upper limb (26.7%), six on the right lower limb (40.0%), and two on the left lower limb (13.3%).

A correlation was identified between the healing outcome and the specific body area affected, showing a statistical significance ($p > 0.047$). Patients with left upper limb injuries had less favorable healing outcomes compared to those with right lower limb injuries. While injury location may influence healing process, causality cannot be determined from this analysis, and other factors may affected the outcomes.

Lesion Evolution Assessment

A statistically significant difference was observed in the measurements of area, circumference, length and width of the lesions throughout the three evaluations ($p < 0.05$) (Table 1). *Post hoc* analysis with the Wilcoxon *signed-rank* test was performed with Bonferroni correction applied, resulting in a significance level set at $p < 0.017$. Significant reductions in lesion area measurements were observed between the first and second evaluations ($p = 0.001$), the second and third evaluations ($p = 0.017$), and the first and third evaluations ($p = 0.012$). A similar significant decrease was noted in lesion circumference across all evaluation points ($p < 0.017$). For lesion length measurements, there was a significant reduction observed between the first and second evaluation ($p = 0.005$) as well as between the first and third evaluation ($p = 0.012$). Similarly, lesion width data demonstrated a significant reduction between the first and second evaluations ($p = 0.001$) and between the first and third evaluations ($p = 0.012$).

Table 1 - Measurements evaluation of the lesiones remaining areas (unhealed regions).

REVISTA ENFERMAGEM ATUAL IN DERME

Evaluation / Measurement	First (1)	Second (2)	Third (3)	P-value[1]	P- value[2]	P- value[3]	P- value[4]
Area (cm²), average	22.25	17.36	6.71	0.001	0.001	0.017	0.012
Range	3.2 – 134.6	1.6 – 119.6	1.2 – 10.2				
Circumference (cm), average	13.4	13.42	9.75	0.001	0.011	0.017	0.012
Range	3.0 – 43.8	5.11 – 40.5	4.5 – 12.7				
Length (cm), average	5.82	5.27	3.73	0.001	0.005	0.018	0.012
Range	2.20 – 15.4	1.90 – 14.9	1.80 – 5.5				
Width (cm), average	3.80	3.17	2.40	0.002	0.001	0.050	0.012
Range	1.70 – 12.10	1.02 – 11.40	0.90 – 3.20				

[1] Friedman Test. Comparison between 1 vs 2 vs 3.

[2] Wilcoxon Signed Ranks Test. Comparison between 1 vs 2.

[3] Wilcoxon Signed Ranks Test. Comparison between 2 vs 3.

[4] Wilcoxon Signed Ranks Test. Comparison between 1 vs 3.

Description of wound healing time

Table 2 shows the initial area of fifteen lesions at the first and last evaluation, and the total healed area in square centimeters (cm²) and percentage (%) by the end of follow-up. The shortest follow-up was 14 days with a 70.49 cm² starting area and 27% healed. The longest was 93 days with a 134.63 cm² starting area and 100% healed, using 2 and 3 dressings, respectively. Most lesions were small (8/15), followed by medium (5/15) and large (2/15).

Table 2 - Area of lesions, follow-up time, number of dressings used and mean wound size assessments.

Patient	Initial Area (cm²)	Final Area (cm²)	Healed Area (cm²)	Follow-up time (days)	Dressings used
001	3.59	3.2	0.39 (11%)	93	4
002	6.38	0	6.38 (100%)	60	2
003	13.66	0	13.66 (100%)	92	3
004	5.06	0	5.06 (100%)	63	2
005a	17.8	0	17.8 (100%)	90	3
005b	13.0	0	13.0 (100%)	90	3
006	28.33	9.33	19.0 (67%)	61	3
007	7.67	0	7.67 (100%)	60	2

REVISTA ENFERMAGEM ATUAL IN DERME

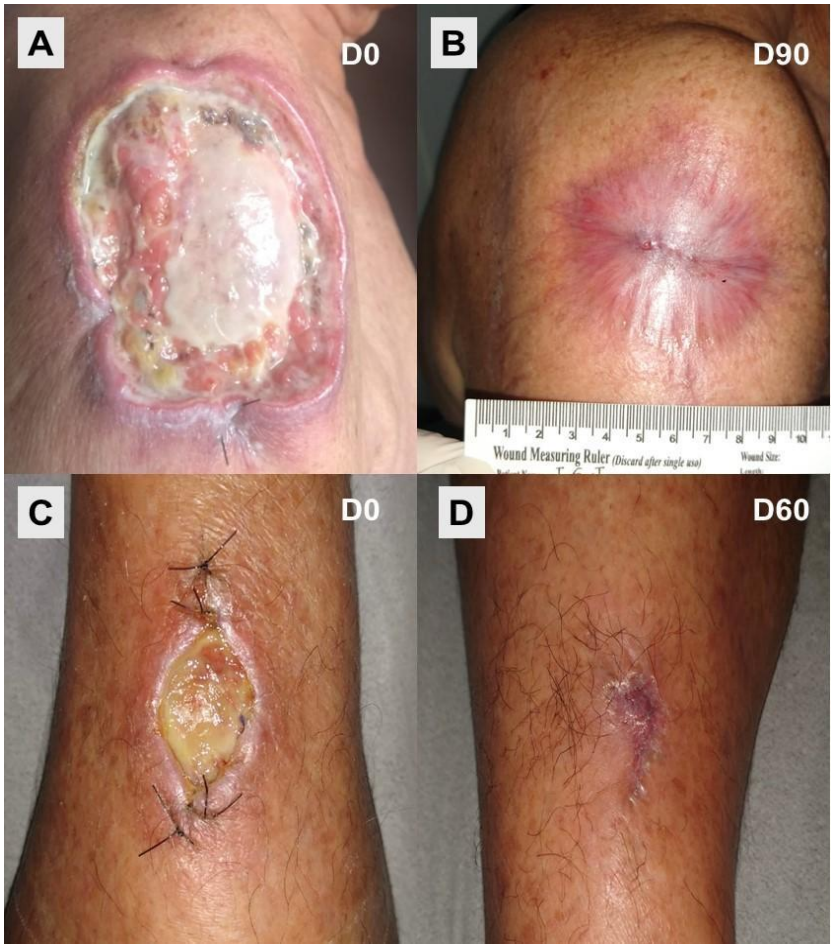
	008	8.53	0	8.53 (100%)	61	2
	009	5,.08	0	5.08 (100%)	58	2
	010	3.26	1.26	2.0 (61%)	63	3
	011	3.24	0	3.24 (100%)	59	2
	012	13.03	9.36	3.67 (28%)	58	3
	013	70.49	51.35	19.14 (27%)	14	2
	014	134.6	0	134.6 (100%)	93	3
Average lesion size	Small (>10 cm²)	5.35	0.56	4.79 (84%)	64.63	2.38
	Medium (entre >10 e ≤ 50 cm²)	17.16	3.74	13.43 (79%)	78.20	3
	Large (> 50 cm²)	102.5	25.68	76.89 (64%)	53.50	2.50

In Figure 2, the cases of patients 14 and 09 respectively can be seen, where a total healed area of 100% was obtained using PolyTissue® dressings. As seen in Figure 2A, patient 14 presented an Operative Wound (OW) containing a medium amount of exudate, non-adhered edges and slightly granular tissue. In this case, the PolyTissue® dressing was used in the spongy presentation, providing greater comfort to the patient, who was monitored for 90 days until complete healing of the OW was achieved (Figure 2B).

Its possible observe in Figure 2C, patient 09 presented a moist OW, with regular and adherent edges. In this case, the PolyTissue® dressing in the microperforated presentation was used, providing a mechanical barrier between the wound and the external environment, allowing monitoring of the healing stage without removing the dressing. The patient was followed for 60 days until complete healing of the OW was achieved (Figure 2D).

Figure 2 - Assessment of wound appearance (Patients 14 and 09 at 90 days and 60 days of follow-up, respectively). (A) D0, moist wound with medium amounts of seropurulent exudate, with edges not

adhered to the wound bed, little predominant granulation tissue, slough, fibrotic tissue, wound treated with CB in the spongy presentation; (B) D90, healed wound; (C) D0, moist wound with regular and adhered edges, with granulation tissue, slough, wound treated with CB in the microperforated film presentation; (D) D60, healed wound.



Source: Researcher's personal collection.

Clinical Progression of Lesions

The lesions' morphological characteristics and the pain parameters were compared based on MEASURE, considering two specific points in time: the initial (D0) and the final evaluation. In the initial evaluation, 53.3% of the wounds were classified as small. However, in the final evaluation, this proportion increased to 86.7%. Medium-sized wounds were present in 33.3% of initial cases and dropped to 6.7% by the final evaluation. Large wounds were found in 13.3% of cases initially and 6.7% by the final evaluation. A statistically significant difference was observed in the evolution of lesion sizes between the two time points ($p = 0.034$).

Regarding bacterial content, all wounds at both time points were classified as clean. Tissue analysis indicated that the necrosis was present in 6.7% of wounds during the initial evaluation, but none were observed in the last. Epithelialization was absent at any time point. Slough appeared in 40% of wounds initially and decreased to 6.7% by the final evaluation. Granulation increased from 53.3% at the first evaluation to 93.3% at the last, indicating higher tendência for granulation at the final point. There

REVISTA ENFERMAGEM ATUAL IN DERME

was a statistically significant difference in tissue characteristics (p = 0.046).

In the exudate amount analysis, 53.3% of responses showed no exudate in the initial evaluation increasing to 86.7% in the final. Small amounts of exudate were observed in 26.7% of the responses in the initial assessment, decreased to 13.3% in the last. The mean amount of exudate was documented in 20% of responses during the initial assessment, with no occurrences noted in the final assessment. A statistically significant difference in the amount of exudate was also observed in relation to the progression of the lesions (p = 0.046).

The exudate characteristics showed that 26.7% of the wounds initially had serous exudate, but it was absent in the final evaluation. Sanguineous exudate was present in 13.3% of the cases, decreasing to 6.7% by the final evaluation. In the final assessment, serosanguineous exudate was observed in 6.7% of the cases. Furthermore, seropurulent exudate was noted in 6.7% of the cases initially, with no instances of purulent or fibrous exudate recorded at any time.

The evaluation of wound edges showed that 80% of the wounds in the first assessment had adhered edges, while this characteristic was observed in 100% of the wounds in the final. Non-adhered edges were present in 6.7% of the wounds during the first evaluation, but there were no cases in the final. No indistinct, macerated, thickened, or fibrotic edges were observed at any time points, and hyperkeratin was detected in 13.3% of the wounds in the initial assessment but was absent in the final one. Additionally, no patients reported pain throughout the evaluations.

DISCUSSION

The study evaluated fourteen patients, with a majority being males (78.6%). This data differs from the Brazilian National Cancer Institute's (INCA) estimate for each year of the 2020/2022 triennium, which predicts 176,930 new cases of basal cell and squamous cell skin cancer in Brazil, comprising 83,770 men and 93,160 women [43].

The average age was 64.4 years, with 66% (10 individuals) being over the age of 60. According to data from the World Health Organization (WHO), non-melanoma skin cancers (NMSC) are common malignant tumors in Brazil. They mainly occur in individuals over 60 years of age and constitute approximately 10% of all new cancer cases diagnosed in this age group, following prostate, breast, and gastrointestinal cancers [44].

In terms of marital status, it was found that 9 out of 14 participants (64.3%) in this study were married, and among these, 5 individuals (55.6%) experienced complete healing of the lesion. While married individuals may tend to adopt healthier lifestyle habits, such as greater attention to health and increased social support, the relationship between marital status and non-melanoma skin cancer remains unclear [45]. Emotional and social support, along with shared responsibility, directly influence seeking specialized health care. Partners encourage routine checkups, attending medical

REVISTA ENFERMAGEM ATUAL IN DERME

appointments, and seeking treatment for health issues [46].

The majority of participants (64.3%) resided in the metropolitan area, with five of these individuals (55.6%) achieving complete healing of the lesion. Residence in Recife and/or the metropolitan region likely facilitated continuous treatment and consistent evaluations, owing to the availability of transportation and proximity to the treatment facility [47].

Among the participants identified as smokers, five individuals (35.7%) achieved complete healing of their lesions during the study period. Research conducted at the University of Leeds involving 700 melanoma patients indicates that smokers have a 40% reduced probability of surviving skin cancer, as smoking exacerbates the condition [48]. Furthermore, several factors influence wound healing, including smoking [49]. Smoking is correlated with delayed healing, increased risk of wound infection, and dehiscence [50].

Regarding the identified comorbidities, 42.9% of patients presented with arterial hypertension, and 21.4% had diabetes mellitus. Notably, only one patient achieved complete healing of the lesion. Patients with diabetes often experience delayed tissue repair in wounds due to excessive production of reactive oxygen species, reduced nitric oxide levels, and decreased responsiveness to growth factors and proteins involved in the insulin signaling pathway. This condition, coupled with the wound's location, further slows the healing process due to the increased probability of mechanical trauma to which the lower limbs are prone and their specific circulatory characteristics [49, 51].

The study observed that 11 out of 14 participants (73.3%) had NMSC of the histological type squamous cell carcinoma (SCC). As reported by INCA (2022), NMSC represents the most common type of cancer in Brazil, constituting approximately 30% of all documented malignant tumors within the country. Basal cell carcinoma (BCC) and SCC represent 95% of all skin cancer cases. Specifically, SCC accounts for 21.7% of malignant skin tumor cases. Although it is the least common type, SCC is the most aggressive and, if not properly treated, can result in significant mutilations [43,45,52].

No statistical difference was found between the histological type of lesions and the healing outcome ($p > 0.05$). However, the area of the body affected was associated with the healing outcome ($p < 0.047$). It is important to note that this study's sample size was limited, so conclusions should be drawn cautiously. Among the six participants (40%) with lesions on the right lower limb, four (66.7%) achieved complete healing, possibly due to factors like sun exposure. For instance, the legs are often exposed to sunlight in warmer environments or during outdoor activities.

Excessive sun exposure is one of the main risk factors for the development of skin cancer [47]. However, the lower limbs generally do not receive the same attention in terms of sun protection, compared to more visible areas of the body, such as the face and arms. As a result, legs receive less sunscreen and protective clothing,

REVISTA ENFERMAGEM ATUAL IN DERME

leading to more sun exposure [45]. Additionally, people tend to pay less attention to skin care on the legs compared to other body regions, which may contribute to the prevalence of non-melanoma skin cancer in this area [52].

There was a statistically significant difference in the reduction of the area, circumference, length and width of the lesions, comparing the measurements of the initial and final evaluations of the lesions (Table 1). Similar data were found in the study by Silva et al. (2021), where 20 patients in the experimental group with active chronic venous ulcers were treated with BC dressing in hydrogel and microperforated film forms [53]. The results showed a 28% reduction in the mean total area of the lesions (p=0.029) and increased epithelialization, along with a decrease in the amount of exudate [53].

In the study carried out by Maia et al. (2020), the BC dressing was applied to patients with lower limb wounds, and the authors indicated a reduction in the wounded area and pain decreased [54]. BC dressings have been employed in treating various wound types, demonstrating significant benefits in tissue regeneration, epithelialization, and pain management. Clinical trials involving different wound categories have shown that BC dressings can effectively induce granulation tissue formation, reduce wound depth, and promote re-epithelialization [53-55]. Table 3 shows the results of using BC dressings for treating various types of wounds, evaluated according to the MEASURE system.

Table 3 - Efficacy of BC dressings in different wound types

Reference	Type and Location of Wound	Treatment (BC Presentation)	N° patients	Results	p-value
				Characteristics and Healing Time	
Correia et al., 2024	Infected wounds (in vitro)	Hydrogel	N/R*	Prevention of biofilm formation	N/R*
Silva, et al., 2021	Lower limbs wound	Perforated film and Hydrogel	39	Increased epithelialization, reduction of wound area	< 0.001
Magalhães et al., 2020	Wound coverage for skin autografts	Perforated film	20	Decreased pruritus and pain, good adhesion, wound epithelialization in 15.8 days	≤ 0.05
Oliveira et al., 2020	Nail bed after avulsion	Sponge and Perforated film	26	Decreased pruritus and pain, adhesion re-epithelialization and preservation of the nail bed after an observation period of 180 days	≤ 0.05

REVISTA ENFERMAGEM ATUAL IN DERME

Oliveira et al., 2019	Wounds in general	Sponge and Hydrogel	10	Granulation tissue induction and wound depth reduction in 30 days	≤ 0.05
Maia et al., 2019	Lower limbs wounds	Perforated film and Hydrogel	24	Wound area reduction, epithelialization increased, amount of exudate decreased in 30 to 180 days of observation.	≤ 0.05
Silveira F. et al., 2016	Tympanic perforation	Compact film	40	Reepithelialization and closure of the tympanic membrane over a period of 30 days	≤ 0.05
Cavalcanti et al., 2017	Lower limbs wound	Perforated film	25	Wound area and pain reduction	≤ 0.05
Martins et al.,2013	Operative wounds	Perforated film	60	Tissue regeneration, wound protection and complete healing between the 8th and 10th day	N/R*
This Work	Operative wounds	Perforated film, Compact film, Hydrogel and Sponge	14	Wound area reduction and pain decreased. Complete healing within 120 days	≤ 0.05

*N/R Data not reported in the study

The shortest follow-up for lesions was 14 days, starting with an area of 70.49 cm² and achieving 27% healing. The longest follow-up was 93 days, beginning with an area of 134.63 cm² and achieving 100% healing. Out of the 14 patients, 5 did not complete the follow-up due to death, tumor recurrence, or treatment abandonment. Data from these patients were analyzed based on their participation period.

In medium and large lesions, BC film was used with BC hydrogel and it improved dressing fixation, allowing for longer stays and fewer changes [34]. Additionally, coverings that remain on the lesion for longer can reduce treatment costs [53].

Pain during dressing changes is noted as a common issue [32]. In this study, patients reported no pain during dressing changes. Reducing pain during dressing changes can enhance patients' quality of life by providing a greater sense of control over their treatment and lessening the injury's impact on their daily activities [56].

Previous research suggests that pain episodes can substantially affect patient adherence to treatment. Another investigation utilizing BC dressings in patients with ischemic wounds reported pain episodes associated with distress, particularly during dressing changes [55].

No adverse events related to PolyTissue® dressings were reported in this study. However, literature describes dermatitis and pain from special dressings in skin wound treatment, which concerns health professionals and patients [57]. Special dressings are designed to promote healing and protect wounds, but they can cause skin irritation and discomfort if not selected and applied properly. Therefore, it is

REVISTA ENFERMAGEM ATUAL IN DERME

important to evaluate the patient's skin carefully before applying the dressing [57]. When selecting the appropriate dressing and presentation for a wound, it is important to consider the type of wound, its location, and the individual needs of the patient. The skin around the dressing should be regularly monitored, and gentle techniques should be used for its removal to minimize trauma and reduce pain associated with the treatment [57, 58, 59].

Palácio et al. (2024) highlighted in their systematic review that BC dressings excel over conventional ones due to their biocompatibility, biodegradability, and exudate absorption, which maintains a moist environment and allows gas exchange. They also protect the wound bed by serving as a mechanical barrier, supporting cells, inducing cell migration and proliferation, and promoting effective tissue regeneration [57].

In a previous study conducted by Carvalho et al. (2025), BC dressing confirmed be highly pure, crystalline, and thermally stable. Key properties such as nanofibril content, transparency, porosity, tensile strength, water vapor permeability, and in vitro degradation indicated that this material is ideal for medical applications, particularly as a dressing after sterilized by irradiation [12].

As this study represents a pioneering investigation into the application of cellulose dressings (PolyTissue®) for surgical wounds following tumor resection, each assessment of the dressing during participant follow-up also entailed evaluating the suitability of the presentation used to address the wound's requirements. At each dressing change, additional instructions were given to participants to ensure consistent home treatment with the PolyTissue® presentations. This process helped determine the most suitable presentation based on the specific wounds characteristics. These findings offer valuable insights for future studies with the same population, indicating potential directions for further research. This approach enabled a detailed observation of the wounds' responses to different dressing presentations.

CONCLUSIONS

Based on the obtained results, it can be concluded that the BC dressing (PolyTissue®), available in presentations smooth, perforated, hydrogel, and spongy forms, facilitated the healing process of lesions resulting from tumor resection of non-melanoma skin cancer. This dressing effectively covered the wound area, including its extension, width, and length, fully healing the wounds in an average of 68 days. Additionally, there were no reports of pain during the application and removal of the dressing. The Wilcoxon signed-rank test for wound healing progression showed statistical significance for all evaluations conducted, rejecting the null hypotheses and indicating a statistical difference between the averages obtained.

In previous research, the physical and chemical characteristics of PolyTissue® were analyzed and scientifically detailed, confirming BC as an ideal candidate for applications in regenerative medicine, aiding in the re-epithelialization of surgical wounds after tumor

REVISTA ENFERMAGEM ATUAL IN DERME

resection, thus supporting the findings of the present study.

These findings suggest that BC dressings could be a promising option for treating surgical wounds from non-melanoma skin tumor resections. PolyTissue® ability to reduce wound size and provide patient comfort may enhance clinical practice, leading to a more effective and less painful recovery after skin cancer-related surgeries.

However, since this is a pioneering research in the use of PolyTissue® in surgical wounds resulting from tumor resection, there is still a need for complementary studies, which should aim to expand the application of the dressings, through multicenter clinical research and increase the sample size to confirm the results obtained.

FINANCIAL SUPPORT

This study was partially funded by the National Council for Scientific and Technological Development (CNPq): J.L.A.A. [CNPq/MCTI 424123/2021-5]; M.M.A. [CNPq/MCTI 382845/2023-4]; F.C.M.P [CNPq/MCTI 350439/2022-2] and the Science and Technology Support Foundation of the State of Pernambuco (FACEPE): L.C.M. [FACEPE BFP-0093-4.01/24].

ACKNOWLEDGMENTS

Research conducted in collaboration with the POLISA® Biopolymers for Health Ltd., Nuclear Energy Department (DEN), Geoscience and Technology Center (CTG), Federal University of Pernambuco (UFPE) and the Pernambuco Cancer Hospital (PCH).

REFERENCES

1. Leyva-Gómez G, Torres MG, Alcala SA, Chavez SAB, Morfin JCM, Carmen MGD, et al. Development of films from natural sources for infections during wound healing. Cell mol biol (Noisy-le-Grand). 2021;67(1):96-100. doi: 10.14715/cmb/2021.67.1.14.

2. Vokurka S, Pokorna A, Stryja J, Krupova L, Mezera V, Cvek J, et al. Oncology wounds - recommendations for care based on multidisciplinary cooperation. Onkologické rány - doporučení péče vycházející z multioborové spolupráce. Klinicka onkologie: casopis Ceske a Slovenske onkologicke spolecnosti. 2022;35(5):408-20. doi: 10.48095/ccko2022408

3. De Jesus Kappler PH, et al. As Principais Coberturas de Feridas Utilizadas Atualmente e as Opções mais Efetivas Disponíveis [undergraduate thesis]. Manhuaçu: Centro universitários UNIFACIG, 2021. Available from: https://pensaracademico.unifacig.edu.br/index.php/repositoriotcc/article/view/3335

4. Starosta JA, Dos Anjos MCR. “Cantos e saberes”: processo de construção de um documentário sobre plantas medicinais. Rev Eletrônica Comunicação, Informação Inovação em Saúde. 2020;14(1). doi: 10.29397/reciis.v14i1.1748

5. Lopyola CMD, Oliveira RMP. Florence Nightingale e a arte de enfermagem: texto e contexto da Inglaterra Vitoriana. Esc. Anna. Nery. 2021;25(4). doi: 10.1590/2177-9465-EAN-2020-0152

6. Santos HB. A atuação do enfermeiro na prevenção, avaliação e tratamento de feridas: revisão bibliográfica [undergraduate thesis]. Lagarto: Faculdade de Enfermagem, Faculdade Ages; 2022, 68p. Avaliable from: https://repositorio.animaeducacao.com.br/handle/ANIMA/25373

7. Barros CF, De Lima IA, Bunhak EJ. Filmes poliméricos no manejo de feridas: uma revisão. Research, Society and Development. 2022;11(6):e10111628757. doi: 10.33448/rsd-v11i6.28757

8. Chattopadhyay S, Raines RT. Review collagen-based biomaterials for wound healing. Biopolymers. 2014;101(8):821-33. doi: 10.1002/bip.22486.

9. Sinha S. Management of post-surgical wounds in general practice. Aust J Gen Pract. 2019;48(9): 596-99. doi: 10.31128/AJGP-04-19-4921.

10. Castro CMMB, Aguiar JLA, Melo FAD, Silva WTF, Marques EL, Silva DB. Citotoxicidade de biopolímero de cana-de-açúcar. Anais da Faculdade de Medicina da Universidade Federal de Pernambuco, 2004;49(2),119-123.

11. Silveira AA, Dantas MLM, Almeida YMB, Aguiar JLA. Estudo biomecânico de membranas de biopolímero de cana de açúcar perfuradas e contínuas implantadas no celular subcutâneo da parede abdominal de ratos. Anais da Faculdade de Medicina da Universidade Federal de Pernambuco, 2007;52:55-59.

12. Carvalho RSF, Mahnke LC, Palácio SB, Barbosa WT, Hodel KVS, Barbosa JDV, et al. Bacterial cellulose hydrogel produced by Gluconacetobacter hansenii using sugarcane molasses as medium: Physicochemical characterization for wound healing applications, Carbohydrate Polymer Technologies and Applications, 2025;9,100632. doi: 10.1016/j.carpta.2024.100632

13. Cavalcanti LM, Pinto FCM, Oliveira GM, Lima SVC, Aguiar JLA, Lins EM. Efficacy of bacterial cellulose membrane for the treatment of lower limbs chronic varicose ulcers: a randomized and controlled trial. Rev Col Bras Cir. 2017;44(1):72-80. doi: 10.1590/0100-69912017001011.

14. Vilar FO, Pinto FCM, Albuquerque AV, Martins AGS, Araújo LAP, Aguiar JLA, et al. A wet dressing for male genital surgery: A phase II clinical trial. Inter braz j urol. 2016;42(6):1220-27. doi: 10.1590/S1677-5538.IBJU.2016.0109.

15. Lins EM. Membrana de Biopolímero de Cana-de-Açúcar como Remendo em Arterioplastias Femorais em Cães [thesis]. Recife: Centro de Ciências da Saúde, Universidade Federal de Pernambuco; 2007. 97p. Available from: https://repositorio.ufpe.br/handle/123456789/3198

16. Lucena RG. Utilização do Biopolímero de Cana-de-Açúcar como Novo Material para *Sling* Pubo Vaginal: Análise Estereólogica [thesis]. Recife: Centro de Ciências da Saúde, Universidade Federal de Pernambuco; 2007. 81p. Available from: https://repositorio.ufpe.br/handle/123456789/3159

17. Lima FMT. Membrana de Biopolímero de Cana-de-Açúcar como Substituto de Dura-Máter em Ratos Wistar. [thesis]. Recife: Centro de Ciências da Saúde, Universidade Federal de Pernambuco; 2008. 88p. Available from: https://repositorio.ufpe.br/handle/123456789/2940

18. Junior AMC. Caracterização da deposição de fibras colágenas e do potencial lisogênico na bexiga de ratos submetidos a um implante de biopolímero de cana de açúcar [thesis]. São Paulo: Escola Paulista de Medicina, Universidade Federal de São Paulo; 2009. 84p. Available from: http://repositorio.unifesp.br/handle/11600/21638

19. Marques SRB, Lins EM, Aguiar JLA, Albuquerque MCS, Rossiter RO, Montenegro LT, et al. Um novo substituto vascular: arterioplastia femoral em cães com remendo de membrana de biopolímero de cana-de-açúcar – avaliação hemodinâmica e histopatológica. J Vasc Bras. 2007;6(4):309-15. doi: 10.1590/S1677-54492007000400003

20. Silva DB. Miringoplastia com Membrana de Biopolímero e Fáscia Autóloga em Chinchilla laniger [dissertation]. Recife: Centro de Ciências da Saúde, Universidade Federal de Pernambuco; 2006. 46p. Available from: https://repositorio.ufpe.br/handle/123456789/21306

21. Albuquerque MCS. Estudo do biopolímero de cana-de-açúcar como remendo em veias femorais de cães [dissertation]. Recife: Centro de Ciências da Saúde, Universidade Federal de Pernambuco; 2009. 71p. Available from: https://repositorio.ufpe.br/handle/123456789/2936

22. Mayer DLB. Avaliação da resposta inflamatória da bula timpânica do biopolímero da cana-de-açúcar [dissertation]. Recife: Centro de Ciências da Saúde, Universidade Federal de Pernambuco; 2009. 81p. Available from:

https://repositorio.ufpe.br/handle/123456789/2956

23. Coelho MCOC, Carrazoni PG, Monteiro VLC, Melo FAD, Mota R, Tenório Filho F. Biopolímero Produzido a Partir da Cana-de-Açúcar para Cicatrização Cutânea. Acta Cirúrgica Brasileira. 2002;17(1),1-7. doi: 10.1590/S0102-86502002000700003.

24. Silva DBS, Aguiar JLA, Coelho AMARB, Filho ELR. Miringoplastia com enxerto livre de membrana de biopolímero de cana de açúcar e fáscia autóloga em Chinchilla laniger. Anais da Faculdade de Medicina da Universidade Federal de Pernambuco. Recife. 2006;51(1),45.

25. Marques SRB, Lins EM, Aguiar JLA, Albuquerque MCS, Rossiter RO, Montenegro LT, el al. A new vascular substitute: femoral artery angioplasty in dogs using sugarcane biopolymer membrane patch – hemodynamic and histopathologic evaluation. J Vasc Bras. 2007;6(4),309-15. doi: 10.1590/S1677-54492007000400003.

26. Aguiar JLA, Lins E.M, Marques SRB, Coelho CARB, Rossiter RO, Melo RJV. Surgarcane biopolymer patch in femoral artery angioplasty on dogs. Acta Cirúrgica Brasileira. 2007;22(1). doi: 10.1590/S0102-86502007000700015.

27. Rangel AE, Aguiar JL, Lima SV, Vilar F. A new biomaterial for the Treatment of Vesicoureteral Reflux: Experimental Study. Int Braz J Urol. 2006;32(1):184.

28. Fragoso AS, Silva MB, Melo CP, Aguiar JLA, Rodrigues CG, Medeiros PL, et al. Dielectric study of the adhesion of mesenchymal stem cells from human umbilical Cord on a Sugarcane biopolymer. J Mater Sci Mater Med. 2014;25(1):229-37. doi: 10.1007/s10856-013-5056-5.

29. Teixeira FMF, Pereira MF, Ferriera NLG, Miranda GM, Aguiar JLA. Spongy film of cellulosic polysaccharide as a dressing for aphthous stomatitis treatment in rabbits. Acta Cir. Bras. 2014;29(4):231-6. doi: 10.1590/S0102-86502014000400003.

30. Lucena MT, Melo JMR, Lira MMM, Castro CM, Cavalcanti LA, Menezes MA, et al. Biocompatibility and cutaneous reactivity of cellulosic polysaccharide film in induced skin wounds in rats. J Mater Sci Mater Med. 2015;26(2):82. doi: 10.1007/s10856-015-5410-x.

31. Silveira FCA, Pinto FCM, Silva SCNS, Carvalho JCMLC, Aguiar J.L.A. Treatment of tympanic membrane perforation using bacterial cellulose: a randomized controlled trial. Braz J Otorhinolaryngol. 2015;82(2):203-8. doi: 10.1016/j.bjorl.2015.03.015.

32. Oliveira MH, Pinto FCM, Albuquerque AV, Aguiar JLA. Unha cirúrgica de biopolímero de cana de açúcar para preservação do leito ungueal após avulsão. Rev Enferm Atual In Derme. 2020;87(11). doi: 10.31011/reaid-2019-v.87-n.25-art.237.

33. Pinto FCM. Proposta de protocolo para sistematização da assistência de enfermagem na sala de curativos em uma unidade básica de saúde localizada no Rio de Janeiro. Rev Augustus. 2012;34(17). Available from: https://apl.unisuam.edu.br/revistas/index.php/revistaaugustus/article/view/202/212

34. Correia AAV, Campos LAA, Macêdo HLRQ, Coriolano DL, Agreles MAA, Xavier DE, et al. Antibacterial and Antibiofilm Potential of Bacterial Cellulose Hydrogel Containing Vancomycin against Multidrug-Resistant Staphylococcus aureus and Staphylococcus epidermidis. Biology. 2024;13,354. doi: 10.3390/biology13050354.

35. Ministério da Saúde (BR). Agência Nacional de Vigilância Sanitária (RDC 185/2001) Resolução Da Diretoria Colegiada - RDC nº 185, de 22 de outubro de 2001. Available from: https://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2001/rdc0185_22_10_2001.pdf

36. Paterson-beedle M, Kennedy JF, Melo FAD, Lloyd LL, Medeiros V. A cellulosic exopolysaccharide produced from sugarcane molasses by a Zoogloea sp. Carbohydrate Polymers. 2000;42(4),375–83. doi: 10.1016/S0144-8617(99)00179-4

37. Pinto FCM, Oliveira ACAX, Carvalho RR, Carneiro MRG, Coelho DR, Lima SVC, et al. Acute toxicity, cytotoxicity, genotoxicity and antigenotoxic effects of a cellulosic exopolysaccharide obtained from sugarcane molasses. Carbohydrate Polymers. 2016;137, 556-60. doi: 10.1016/j.carbpol.2015.10.071

38. Martins AGS, Lima SVC, Araujo LAP, Vilar FO, Cavalcante NTP. A wet dressing for hypospadias surgery. International Braz J Urol. 2013;39(3),408-13. doi: 10.1590/S1677-5538.IBJU.2013.03.15

39. Keast DH, Bowering K, Evans W, Mackean GL, Burrows C, D'Souza L. MEASURE: A proposed assessment framework for developing best practice recommendations for wound assessment. Wound Repair Regen. 2004;12:1-17. doi: 10.1111/j.1067-1927.2004.0123S1.x

40. Biagioni RB, Carvalho BV, Manzioni R, Matielo MF, Brochado FC, Sacilotto R. Smartphone application for wound area measurement in clinical practice. J Vascular Surgery Cases, Innovations and Techniques, 2021;7(2):258-61. doi: 10.1016/j.jvscit.2021.02.008

41. Faria JPGA. Aplicação móvel para analisar formas bidimensionais e irregulares na saúde-Android [thesis]. Coimbra: Faculdade de Ciências e Tecnologia, Universidade de Coimbra; 2022, 107 p. Available from: https://hdl.handle.net/10316/102130

42. Eberhardt TD, Lima SBS, Lopes LFD, Borges EL, Weiller TH, Fonseca GGP. Measurement of the area of venous ulcers using two software programs. Rev. Latino-Am. Enfermagem, 2016. Available from: https://doi.org/10.1590/1518-8345.1673.2862 doi: 10.1590/1518-8345.1673.2862

43. Instituto Nacional do Câncer. Estimativa 2020 Incidência de Câncer no Brasil. Available from: https://www.inca.gov.br/sites/ufu.sti.inca.local/files//media/document//estimativa-2020-incidencia-de-cancer-no-brasil.pdf

44. Organização Pan-Americana da Saúde. Organização Mundial da Saúde. Câncer. © Organização Pan-Americana da Saúde. Available from: https://www.paho.org/pt/topicos/cancer

45. Barreiro LEMS, Brito YR. Fatores Relacionados à Ocorrência de Câncer de Pele na População Brasileira: uma Revisão de Literatura [undergraduate thesis]. Guanambi: Centro Universitário - UNIFG, Bahia; 2022, 16p. Available from: https://repositorio.animaeducacao.com.br/handle/ANIMA/25326

46. Mccaughan D, Sheard L, Cullum N, Dumville J, Chette I. Patients perceptions and experiences of living with secondary intention surgical wound healing: a qualitative study. Int J Nurs Stud, 2018;77:29-38. doi: 10.1016/j.ijnurstu.2017.09.015

47. Newton-Bishop J, Muralidhar S, Filia A. Vitamin D–VDR Signaling Inhibits Wnt/β-Catenin–Mediated Melanoma Progression and Promotes Antitumor Immunity. Cancer Res, 2019;79(23):5986–98. doi: 10.1158/0008-5472.CAN-18-3927

48. Shamji FM, Beauchamp G. Can Biologic Aggressiveness and Metastatic Potential of Primary Lung Cancer Be Predicted from Clinical Staging Alone? Thorac Surg Clin, 2021;31(3):357-66. doi: 10.1016/j.thorsurg.2021.04.010

49. Beyene RT, Derryberry SL, Barbul A. The Effect of Comorbidities on Wound Healing. Surgical clinics North America, 2020;100(4):695–05. doi: 10.1016/j.suc.2020.05.002

50. Kean J. The effects of smoking on the wound healing process. J wound care, 2010;19(1):5–8. doi: 10.12968/jowc.2010.19.1.46092

51. Lima MHM, Araujo EP. Diabetes Mellitus e o Processo De Cicatrização Cutânea. Cogitare Enfermagem, 2013;18(1). ISSN 2176-9133. Available from: https://revistas.ufpr.br/cogitare/article/view/31323/20032

52. Ward T, Medina-Lara A, Mujica-Mota RE, Spencer, AE. Considerações de Heterogeneidade em Análises Econômicas de Câncer. Valor em Saúde, 2020;23, p.447.

53. Silva LG, Albuquerque AV, Pinto FCM, Carvalho RSF, Aguiar JLAA, Lins EM. Bacterial cellulose an effective material in the treatment of chronic venous ulcers of the lower limbs. J Materials Science: Materials in Medicine. 2021;32(7):p79. doi: 10.1007/s10856-021-06539-1

54. Maia AL, Lins EM, Aguiar JLA, Pinto FCM, Rocha FA, Batista LL, et al. Curativo com filme e gel de biopolímero de celulose bacteriana no tratamento de feridas isquêmicas após revascularização de membros inferiores. Revista Do Colégio Brasileiro De Cirurgiões, 2020;46, e20192260. doi: 10.1590/0100-6991e-20192260

55. Oliveira GM, Vieira JMS, Silva JGM, Albuquerque ELMS, Albuquerque AV, Aguiar JLA, et al. Curativo de celulose bacteriana para o tratamento de lesões por pressão em pacientes hospitalizados na unidade de terapia intensiva (UTI) de um Hospital Universitário Em Recife, Pernambuco. Revi Enferm Atual In Derme, 2019;87(1). doi: 10.31011/reaid-2019-v.87-n.especial-art.163

56. Paiva MPF, Andrade LA, Lemos LAP, Rodrigues MEG, Costa JEF, Duarte IN, et al. Avaliação do conhecimento da população acerca do câncer de pele. Rev Eletrônica Acervo Saúde. 2023;23(10), e14226. doi: 10.25248/reas.e14226.2023

57. Palácio SB, Penello SO, Monteiro CTM, Marchetti RCH, Graeff AA, Mahnke LC, et al. Aplicação de curativos de celulose bacteriana na cicatrização de feridas crônicas e complexas: Tendências e perspectivas. Research, Society and Development. 2024;13(2), p. e1813244920-e1813244920. doi: 10.33448/rsd-v13i2.44920

58. Adderley U. Wound care in 2021. Br J Community Nurs, 2021;1(26):5. doi: 10.12968/bjcn.2021.26.Sup3.S5

59. Younis I. Dehisced surgical wound. J Wound Care, 2020;1(29):18-9. doi: 10.12968/jowc.2020.29.Sup10a.S18

Authorship criteria (authors' contributions)

Santos KM designed the study, collected data, analyzed and interpreted the data, and wrote the manuscript. Mahnke LC analyzed and interpreted the data, wrote and revised the manuscript. Arcoverde MM participated in the technical development and therapeutic innovation of the tested product. Aguiar JLA critically reviewed the work and approved the final version of the manuscript. Pinto FCM supervised the research, analyzed and interpreted the data, critically reviewed the work, and approved the final version of the manuscript.

Declaration of conflict of interest

Nothing to declare.

Scientific Editor: Francisco Mayron Morais Soares. Orcid: https://orcid.org/0000-0001-7316-2519