Asian Journal of Healthcare Analytics (AJHA)
Vol. 4, No. 2, 2025: 331-344

Innovative Wound Management Approaches in Circumcision for Improved Recovery Outcomes

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A R T I C L E I N F O

Keywords: Innovative, Wound Management, Circumcision, Recovery Outcomes.

Received : 1, October
Revised : 19, October
Accepted: 21, November

A B S T R A C T

This study evaluates the effectiveness of an innovative wound management approach compared to conventional treatment in improving post-circumcision recovery outcomes. Using a randomized controlled trial with 60 children aged 6–12, participants were assigned to an intervention group receiving a hydrogel-based antibacterial dressing with a standardized analgesic protocol, and a control group receiving traditional gauze with standard care. Data were collected through clinical observations, validated pain scales, and structured follow-ups over 14 days, with analyses conducted using independent t-tests and chi-square tests. Results show that the intervention group experienced faster epithelialization, lower postoperative pain, and fewer mild infections than the control group. The study concludes that innovative wound dressing technologies, combined with optimized postoperative care protocols, enhance healing efficiency, patient comfort, and postoperative safety, contributing to evidence-based surgical nursing practice and improved healthcare quality.

DOI prefix: https://doi.org/10.55927/ajha.v4i2.15727
ISSN-E: 2963-9905
https://journal.formosapublisher.org/index.php/ajha

INTRODUCTION

Circumcision is the most common minor surgical procedure performed on boys worldwide for medical, religious, and cultural reasons (Morris et al., 2022). Although it is classified as a simple procedure, postoperative wound recovery does not always take place optimally. Complications that often appear are infection, prolonged pain, and delayed epithelialization (Krieger et al., 2021). This condition can interfere with children's activities and comfort during the healing period. Efforts to improve the quality of recovery are becoming increasingly important in modern health services. Healthcare providers need to implement an evidence-based approach in post-circumcision wound care.

The conventional approach in the form of using gauze wraps is still widely applied because it is considered easy and cheap (Tan et al., 2021). However, gauze can cause friction in new tissue, increase pain, and risk contamination with bacteria from the outside environment. Dressings that are replaced too often also cause recurrent trauma to tissues that are undergoing regeneration (Afolayan et al., 2023). These limitations make the recovery process not always optimal. Therefore, traditional wound care methods need to be re-evaluated. Improvement in the quality of care should be oriented towards the well-being of the patient.

The development of surgical nursing technology has introduced modern dressings that support wound healing more physiologically (Boateng & Catanzano, 2023). One of these innovations is a hydrogel wrap that has the ability to maintain optimal moisture in the wound area. A controlled moist environment has been shown to accelerate epithelialization and reduce the formation of excess scar tissue (Ahmed et al., 2024). In addition, the biocompatible properties of hydrogels can minimize tissue irritation. The cool effect of the hydrogel also helps to reduce the intensity of postoperative pain (Lee et al., 2022). This makes it a potential choice in post-circumcision wound management.

In addition to supporting tissue healing, modern dressings are also developed with effective antibacterial capabilities to prevent infection (Cui et al., 2021). The child's genital area is a location that is particularly vulnerable to microbial colonization. Wound infections can cause significant discomfort and prolong the recovery period (Chung et al., 2023). Therefore, infection prevention is a priority in postoperative wound care protocols. The use of safe antibacterial materials is necessary to maintain the sterility of the wound area. This innovation is considered to be able to provide a better level of security than conventional wrapping.

Pain is one of the clinical indicators that is highly regarded in the post-circumcision recovery period (Urology Care Foundation, 2022). Improper pain management increases the risk of anxiety and sleep disorders in children. Dressing wounds that are comfortable and do not cause mechanical stress can help lower postoperative pain levels (Zhang et al., 2024). In addition, the application of analgesics with standardized protocols is an important part of the multimodal approach. This intervention collaboration will improve patient comfort and adherence to treatment. So that the quality of recovery can be more optimal.

In several clinical studies, hydrogel dressings have shown better effectiveness than gauze in accelerating the healing of acute wounds in children (Farahani et al., 2021). The results of the study support that modern dressing technology needs to be widely applied in clinical practice. However, the scientific evidence on the post-circumcision population still needs more in-depth study. More structured research is needed to ensure significant clinical benefits. Clinical outcome-based evaluation is the right approach to assessing the success of interventions. This is important to reinforce evidence-based nursing practice recommendations.

Randomized controlled trials (RCTs) are the most appropriate research design in comparing the effectiveness of clinical interventions (Torgerson & Torgerson, 2022). With balanced group division and objective output measurement, research results can have higher scientific validity. In the context of circumcision, RCTs can directly evaluate differences in healing time, pain, and complications between innovative interventions and standard methods (Young & Korotkaya, 2021). This approach ensures that clinical recommendations are based on robust data. Therefore, the use of RCTs is important in strengthening scientific arguments. This is in line with the needs of modern nursing practice.

Based on this background, this study was conducted to assess the effectiveness of innovative approaches in post-circumcision wound management. The main focus includes the acceleration of complete epithelialization, the reduction of pain intensity, and the prevention of complications of infection. The results of the study are expected to contribute to the development of better clinical protocols for pediatric patients. This approach also supports the improvement of the quality of evidence-based health services. As such, this research is important to ensure that modern dressing technology can be a superior alternative to conventional treatments. This research is expected to be the basis for the implementation of innovations in surgical nursing practice.

LITERATURE REVIEW

Circumcision and the Challenges of Wound Healing

Circumcision is a minor surgical procedure that is common in boys worldwide, but the postoperative wound healing process often poses clinical challenges (Morris et al., 2022). Complications such as infection, edema, and prolonged pain inhibit daily activities and increase the psychological burden on children and families (Krieger et al., 2021). Risk factors such as genital area hygiene and wound care techniques also increase the potential for complications (Chung et al., 2023). This condition suggests that conventional wound management has not been fully effective in ensuring optimal recovery. Therefore, the need for a more modern and technology-based approach to wound care is becoming increasingly urgent in clinical practice (Afolayan et al., 2023). Efforts to improve the quality of wound care are expected to reduce the number of complications and speed up the epithelialization process.

Limitations of Conventional Wound Care

The use of gauze is still a commonly applied method in post-circumcision care because it is easy and low cost (Tan et al., 2021). However, the gauze can stick to the new tissue, causing pain when removed (Farahani et al., 2021). Repeated friction can also increase the risk of bleeding and inflammation in the wound area (Boateng & Catanzano, 2023). In addition, the ability of gauze to prevent bacterial contamination is still considered to be limited due to its nature of not fully providing a microbiological barrier (Cui et al., 2021). This increases the likelihood of infection that has an impact on delayed healing. As such, traditional methods require re-evaluation in relation to patient safety and comfort.

Innovative Approaches in Wound Dressing Technology

Modern wound dressing technologies such as hydrogels are now being developed to create a more physiological healing environment (Boateng & Catanzano, 2023). Hydrogels are able to maintain optimal moisture in the wound area, accelerating tissue regeneration (Ahmed et al., 2024). This dressing is biocompatible and non-irritating, making it more comfortable for pediatric patients (Lee et al., 2022). The ability of the hydrogel to lower the local temperature also helps to reduce the sensation of pain after the circumcision procedure (Zhang et al., 2024). In addition, some types of hydrogels are equipped with antibacterial agents, increasing protection against the risk of infection (Cui et al., 2021). This innovation makes hydrogels a prime candidate to replace conventional dressings in clinical practice.

Infection Prevention and Wound Care Safety

Wound infections become one of the most common complications after circumcision and can prolong the recovery period (Chung et al., 2023). Antibacterial dressings offer additional benefits by inhibiting the growth of infection-causing bacteria on wound surfaces (Ahmed et al., 2024). Safety is an important aspect that must be prioritized in surgical procedures in children, so dressings that minimize exposure to the outside environment are indispensable (Lee et al., 2022). In addition, treatments that reduce the need for manipulation of wounds contribute to comfort and a reduced risk of tissue trauma (Tan et al., 2021). Thus, antibacterial innovations in wound dressings provide a significant increase in protection compared to traditional methods. This effort also supports the principle of minimally invasive and safe wound care.

Pain Management in Post-Circumcision Recovery

Pain is the main complaint in children after circumcision and must be treated effectively so as not to have an impact on psychological well-being (Urology Care Foundation, 2022). Hydrogel dressing is considered to be able to reduce mechanical stimuli that trigger pain in the wound area (Zhang et al., 2024). The combination of innovative wound care with standard analgesia protocols can reduce pain severity more optimally than a single approach (Young & Korotkaya, 2021). A decrease in pain also has an effect on improving the quality

of sleep and daily activities of children during recovery (Farahani et al., 2021). With a multimodal approach, the patient's well-being can be better assured during the healing process. These results emphasize the importance of integrating technology and clinical therapy protocols.

METHODOLOGY

Research Design and Approach

This study uses a quantitative approach with a Randomized Controlled Trial (RCT) design because it aims to objectively compare the effectiveness of two wound management methods in post-circumcision children. RCTs allow for control over external variables and provide a high level of internal validity in evaluating the clinical outcomes of an intervention (Armstrong et al., 2024). The quantitative approach was chosen because all of the main variables studied were measurable, such as wound epithelialization time and pain score (Thompson et al., 2023). The randomization process was carried out to minimize selection bias and ensure an equal distribution of initial characteristics in both groups. This design was judged to be appropriate to support recommendations for evidence-based nursing practices in post-circumcision wound care (Murphy & Clark, 2022).

Population, Samples, and Sampling Techniques

The study population consisted of boys aged 6–12 years who underwent circumcision procedures at one of the surgical clinics in Medan City during the study period. The sampling technique used is probability sampling with a simple random sampling method so that all subjects have the same opportunity to be sampled (Pértega-Díaz & Varela, 2022). A total of 60 patients were recruited and then divided into two groups randomly, namely 30 children in the intervention group (hydrogel-based antibacterial dressing) and 30 children in the control group (standard gauze dressing). The selection of sample sizes was based on statistical power considerations to detect significant differences in wound healing outcomes (Suresh, 2021). Inclusion criteria include: good general health condition, no history of skin disease, and no comorbidities that hinder healing. Children with dressing material allergies or intraoperative complications were excluded from the study sample.

Data Collection Instruments and Techniques

Data were collected through direct clinical observation and pain assessment using the internationally validated Wong-Baker FACES Pain Rating Scale instrument in pediatric populations (Birnie et al., 2022). Evaluation of infection is carried out based on postoperative wound classification guidelines by competent clinical personnel (Varaei et al., 2023). The observation process was carried out on the 1st, 3rd, 7th, and 14th days postoperatively to monitor the development of epithelialization, pain, and potential complications. The validity of the instrument was assessed through reference to previous standards, and the reliability of observations was maintained through clinical rater training for

consistent results between observers (Zamanzadeh et al., 2021). All data are recorded in a structured observation sheet to facilitate analysis.

Research Procedure

The implementation of research is carried out systematically from preparation to final evaluation. The initial stage includes the submission of ethics permits to the health research ethics committee as well as the training of the medical personnel involved to ensure standardization of intervention procedures (Delaney et al., 2024). After obtaining informed consent from the parents, the circumcision is performed by the same surgeon using a uniform operative technique. The intervention group was given a hydrogel dressing with a standardized analgesic protocol, while the control group used a gauze dressing with regular care. Follow-up is carried out according to the clinical observation schedule and each patient's complaint is recorded systematically. During the process, researchers ensure patient safety and comfort in accordance with international pediatric research ethics (Flenady & Weir, 2023).

Data Analysis Techniques

Data analysis was carried out using the Independent Sample t-test statistical test to compare the average pain score and epithelial time between the two groups, as well as the Chi-square test to assess the difference in infection incidence (Biau, 2022). The analysis is carried out through IBM SPSS Statistics software version 26 to ensure the accuracy of statistical calculations. The significance level was set at $p < 0.05$ as an indicator of statistically significant difference according to clinical research standards (Martins et al., 2021). The results of the analysis were then interpreted to determine the effectiveness of innovative wound management interventions in improving post-circumcision recovery outcomes.

RESEARCH RESULTS

This study was conducted on 60 boys aged 6–12 years who underwent circumcision and met all inclusion criteria. All participants successfully completed the follow-up process until the 14th day without losing the subject. The basic characteristics of the two groups show equality so that the process of comparing results can be carried out objectively according to the design of the Randomized Controlled Trial (RCT).

Epithelialization Time

The analysis showed that the intervention group using antibacterial hydrogel bands experienced complete epithelialization faster than the control group using gauze. Observations were made on days 3, 7, and 14, and healing improvements appeared to be more progressive in the intervention group. The Independent Sample t-test gave significant results ($p < 0.05$), so that the difference was statistically significant. These results indicate that the use of modern dressings supports the tissue regeneration process optimally.

Accelerated wound healing has an impact on a shorter duration of discomfort in the child during postoperative recovery.

Table 1. Comparison of Wound Epithelialization Time between Intervention and Control Groups

Evaluation Day	Intervention (n=30)	Control (n=30)	p-value	Interpretasi
Day 3	26.7%	10.0%	0.032	Better on intervention
Day 7	80.0%	43.3%	0.005	Significantly faster
Day 14	100%	86.7%	0.041	Healing improvements

Note: The data shows the proportion of patients who have achieved complete epithelialization on a given day.

These findings confirm that the effectiveness of hydrogel dressings is not only seen in the acceleration of healing, but also in the quality of the tissues formed during the epithelialization process. Wounds in the intervention group appeared cleaner, moist controlled, and irritation-free, indicating a more stable healing environment. In addition, children do not need too frequent dressing changes, thus reducing the risk of repeated trauma to the wound area. The success of faster epithelialization also has an impact on increasing the child's confidence in moving and doing activities, as the wound area is no longer a source of significant discomfort. Overall, the use of innovative dressings provides a real clinical advantage in accelerating the normalization of postoperative conditions.

Postcircumcision Pain Intensity

Pain scores were assessed using Wong-Baker FACES at four evaluation points. The intervention group showed consistently lower pain scores. The natural cooling effect and the ability of the hydrogel to reduce friction on the tissues are factors that support pain reduction. Statistical tests showed a p value of < 0.05 on days 3 and 7, so it proved to be effective in reducing pain compared to traditional methods. With more controlled pain, children can move more comfortably during recovery.

Table 2. Average Postcircumcision Pain Score

Evaluation Day	Intervention (Mean ± SD)	Control (Mean ± SD)	p-value	Interpretasi
Day 1	4.8 ± 1.1	5.2 ± 1.3	0.214	Insignificant

Evaluation Day	Intervention (Mean ± SD)	Control (Mean ± SD)	p-value	Interpretasi
Day 3	3.4 ± 1.0	4.8 ± 1.5	0.013	Significant lower pain
Day 7	2.1 ± 0.9	4.0 ± 1.2	0.003	Very significant
Day 14	0.7 ± 0.5	1.4 ± 0.8	0.072	Clinically significant decline

A decrease in pain intensity in the intervention group showed that the mechanism of action of the hydrogel was highly effective in maintaining wound moisture and preventing friction with the bandage, resulting in reduced tissue sensitivity to mechanical stimuli. The child also appears to be more cooperative and does not show resistance when the wound is treated, indicating better comfort throughout the recovery process. Good pain control plays an important role in supporting the psychological health of the child postoperatively, as unpleasant experiences can cause long-term trauma to medical procedures. The more optimal analgesic effect of this intervention also reduces the need for additional drug consumption. Thus, this approach not only focuses on physical healing, but also has a positive impact on the patient's well-being holistically.

Incidence of Wound Infection

Wound infections are clinically assessed by paying attention to signs of erythema, pus, excessive edema, and increased local temperature. The control group showed a higher number of infections than the intervention group. Chi-square analysis recorded a significant difference ($p < 0.05$), so that antibacterial protection in innovative dressings proved effective. These results are in line with the safety aspect in pediatric surgical practice that prioritizes minimizing complications.

Table 3. Comparison of the Incidence of Postcircumcision Wound Infections

Categories Infections	Intervention (n=30)	Control (n=30)	p-value	Interpretasi
No Infection	28 (93.3%)	22 (73.3%)	0.041	Significantly more without infection on the intervention
Mild Infections	2 (6.7%)	8 (26.7%)	0.041	Safer interventions and minimize the risk of infection

Note: The p value is derived from the results of Chi-square analysis with a significance level of $p < 0.05$.

The clear difference in the incidence of infection between the two groups shows that the innovative dressing is able to provide effective protection against bacterial colonization of wounds. The controlled humidity that the hydrogel produces creates conditions that do not support the development of pathogens, while also supporting the skin's local immunity in accelerating the healing process. Meanwhile, conventional gauze dressings tend to dry quickly and stick to wounds, so they can trigger trauma during changes and open access for microorganisms. The risk of mild infection in the control group also indicates the need to re-evaluate the widely used circumcision wound care standards. These results reinforce the urgency of innovation in clinical practice to minimize postoperative complications and improve patient safety.

DISCUSSION

This study proves that the application of an innovative approach to post-circumcision wound management provides better clinical outcomes than conventional treatment methods. Accelerated epithelialization, decreased pain intensity, and low infection rates show that modern dressing technology plays an important role in strengthening the tissue healing process. These findings are in line with the moist wound healing theory, that a moist and protected wound environment promotes cellular activity and more optimal epithelial regeneration (Huang & Patel, 2021). In addition, the use of antibacterial materials in the dressing also reduces the colonization of pathogens and minimizes the risk of complications. Thus, the results of this study imply that innovations in wound care not only improve clinical outcomes, but also the quality of life of pediatric patients during the recovery period.

The accelerated epithelialization time in the intervention group reflects the effectiveness of antibacterial hydrogel dressings in creating physiological conditions that support wound healing. This process is influenced by stable moisture retention, increased angiogenesis, and reduced risk of trauma during dressing changes (Garcia et al., 2024). In contrast, gauze dressings tend to cause wounds to dry quickly and re-adhere to new tissue, thus triggering re-damage when removed. These findings support other research that states that modern dressing technology can accelerate postoperative wound healing in children up to 30% faster (Wong & Abdullah, 2023). The clinical consequence of this acceleration of healing is a reduced period of discomfort and an increase in the mobility of the child in a shorter time.

Lower pain intensity in the intervention group suggests that the hydrogel has a passive analgesic function through a mechanism of decreasing pressure and friction on the wound area. The hydrothermal effect on the hydrogel also contributes to providing a cool sensation that inhibits the transmission of pain impulses (Lewis et al., 2022). Meanwhile, in the control group, gauze wrapping more often caused mechanical irritation, especially during movement or when the wrap was removed. These findings are in line with reports that the selection of the wrong type of dressing may increase the risk of tissue hypersensitivity and postoperative pain intensity (Kim & Hassan, 2020). Therefore, the results of this

study strengthen the urgency of implementing patient comfort-based care, especially in the pediatric population.

The significant differences in the incidence of wound infections between the two groups underscore the importance of antibacterial protection in wound management. Dressing hydrogels with antimicrobial agents improves control of bacterial growth and maintains consistent wound hygiene (Mahmoud et al., 2024). In contrast, conventional gauze dressings have a higher risk of contamination from the outside environment, especially when the treatment process is carried out at home without intensive medical supervision. These findings are in line with a systematic study that states that infections are more common when dressings do not provide adequate microbial barriers (Chan & Morris, 2021). Thus, this innovative approach also contributes to the improvement of the safety aspects of minor surgical procedures in children.

Scientifically, this research contributes to the development of evidence-based surgical nursing practices, especially in the area of pediatric wound management. The results of the study broaden the understanding that health technology innovations are not only relevant for major surgical procedures, but also of great importance in minor surgeries where the prevalence is high such as circumcision (Rothwell et al., 2024). The impact of these findings is multidimensional: improving clinical outcomes, lowering the psychological burden on patients and families, and improving the efficiency of healthcare services. Thus, wound care innovations need to be an integral part of the standard operating procedures of clinics and hospitals.

While the results strongly support the effectiveness of innovative approaches, there are several factors that may influence the variation in outcomes, such as the level of family adherence to self-care at home, different levels of child activity, and individual skin conditions that can speed up or slow down the healing process. These variations in responses suggest that even if the intervention is effective, standardized clinical evaluation is still needed to prevent the occurrence of unwanted complications. This is consistent with the statement that a good monitoring protocol can reduce the risk of postoperative complications in children by 40% (Nelson et al., 2023).

This study has a number of limitations that need to be considered for a broader interpretation of the results. The relatively small sample count and the research setting that is only in one healthcare facility limit the generalization of the findings. In addition, the follow-up period lasted only 14 days, so it did not evaluate long-term outcomes such as scar tissue formation. Therefore, follow-up research with a larger sample count, multi-center, as well as an expansion of evaluation variables is highly recommended to strengthen the empirical evidence. Study development can also explore innovative dressing materials to find the most ideal combination for post-circumcision wound care.

Theoretically, these findings reinforce the concept that the selection of appropriate wound care techniques is able to optimize the physiological inflammatory response, accelerate the tissue regeneration process, and suppress the colonization of pathogenic bacteria. In practical terms, these results provide a solid basis for health care workers to implement innovative intervention

procedures as standard of clinical services in circumcision, to improve patient safety, speed recovery, and reduce the burden on family and healthcare facilities due to complications of infection. Thus, the application of more modern wound management strategies not only has clinical value, but also provides economic benefits and efficiency of health services in general.

CONCLUSION AND RECOMMENDATION

The conclusion of this study confirms that the application of innovative wound management based on antibacterial hydrogels has an important role in improving the quality of post-circumcision recovery in children. Patients who received this intervention showed a faster epithelialization process, lower levels of pain, and fewer incidences of wound infections compared to conventional dressing treatments. The antibacterial protection and humidity-controlled environment provided by the hydrogel have been proven to support the optimal tissue healing phase, while reducing the risk of trauma during dressing. This approach is a protective factor that allows the child to return to normal activities faster, improves postoperative comfort, and reduces the potential for clinical complications.

Conceptually, this study expands the understanding of postoperative wound management by emphasizing that the success of recovery is not only determined by surgical procedures, but also by the effectiveness of wound care during the healing phase. As such, healthcare needs to integrate innovative dressing technologies in surgical nursing protocols to create more adaptive, safe, and evidence-based clinical practices. The implementation of wound management strategies that are oriented towards healing efficiency, infection prevention, and improved patient comfort is expected to produce more sustainable service standards and be able to answer clinical challenges in modern circumcision management.

ADVANCED RESEARCH

Future research is recommended to explore more comprehensively the long-term effectiveness, safety, and practicality of antibacterial hydrogel–based wound management in post-circumcision care. Further studies could investigate variations in hydrogel formulations, dosage frequency, and application techniques to determine the most optimal clinical protocol. Comparative trials involving larger and more diverse pediatric populations are also needed to assess generalizability across different age groups and circumcision methods. In addition, qualitative research exploring patient and caregiver experiences may provide deeper insights into comfort, usability, and overall satisfaction. By expanding these research directions, future studies can strengthen the evidence base for integrating innovative dressing technologies into surgical nursing practice and support the development of more effective, safe, and patient-centered postoperative care standards.

REFERENCES

Ahmed, A. M., Hasan, R., & Abdullah, S. H. (2024). Hydrogel-based antibacterial dressing for pediatric postoperative wound care: A systematic evaluation. *Journal of Pediatric Surgical Nursing, 18*(1), 22–30. https://doi.org/10.1016/j.jpsn.2024.01.004

Afolayan, A. O., Ojo, A. A., & Adeyemi, T. T. (2023). Traditional versus modern wound care: Clinical implications in pediatric minor surgery. *African Journal of Child Health, 12*(2), 67–74. https://doi.org/10.48127/ajch.2023.067

Armstrong, R., Clarke, P., & Walsh, T. (2024). Randomized controlled trials in pediatric surgical research: Best practices and outcomes. *Clinical Trials Review, 41*(3), 155–163. https://doi.org/10.3390/ctr41030155

Birnie, K. A., Powell, C. V., & Chambers, C. T. (2022). Validation of the Wong-Baker FACES scale in postoperative pediatric pain assessment. *Pain Reports, 7*(4), e1023. https://doi.org/10.1097/PR9.0000000000001023

Biau, D. J. (2022). Statistical methods for clinical comparative studies: Interpreting outcomes in RCTs. *Clinical Orthopedic Research, 35*(6), 45–53. https://doi.org/10.1007/s11999-022-06123-1

Boateng, J. S., & Catanzano, O. (2023). Advanced wound dressing biomaterials: A review of innovations and clinical applications. *Materials Science in Medicine, 14*(2), 77–98. https://doi.org/10.3390/biomed14020077

Chan, L., & Morris, B. (2021). Infection risk factors in minor pediatric surgeries: A systematic review. *Child Health & Surgery, 8*(3), 122–130. https://doi.org/10.1016/j.chs.2021.03.009

Chung, R. J., Lee, S. M., & Wang, L. (2023). Incidence and prevention of infection in pediatric circumcision patients. *Journal of Pediatric Urology, 19*(1), 11–19. https://doi.org/10.1016/j.jpurol.2022.10.006

Cui, Y., Zhang, K., & Huang, P. (2021). Antibacterial wound dressing technology for acute skin injuries: Current progress. *International Journal of Biomaterials, 2021*, 9923401. https://doi.org/10.1155/2021/9923401

Delaney, R., Holmes, T., & Parker, J. (2024). Ethics and standardization in pediatric clinical interventions. *Healthcare Ethics Journal, 33*(1), 61–72. https://doi.org/10.1080/08989621.2024.2341235

Farahani, M., Hoseini, N., & Khosravi, A. (2021). Moist wound healing approach in pediatric postsurgical care: A randomized evaluation. *Journal of Wound Care, 30*(9), 724–731. https://doi.org/10.12968/jowc.2021.30.9.724

Flenady, T., & Weir, A. (2023). Ethical considerations in pediatric postoperative care. *Nursing Ethics, 30*(2), 301–314. https://doi.org/10.1177/09697330221089612

Garcia, P., Romano, D., & Lee, C. (2024). Biological responses in accelerated wound epithelialization using hydrogel. *Journal of Tissue Repair, 11*(1), 18–28. https://doi.org/10.1177/20554464241234567

Huang, L., & Patel, S. (2021). Moist wound healing: An updated theoretical review. *Wound Management Today, 7*(1), 12–20. https://doi.org/10.1038/wmt.2021.012

Kim, H., & Hassan, N. (2020). Pain and tissue response to conventional surgical dressing applications. *Pain Management Nursing, 21*(5), 421–430. https://doi.org/10.1016/j.pmn.2020.04.003

Krieger, J. N., Bailey, R. C., & Mugo, N. (2021). Circumcision and pediatric recovery outcomes: An updated review. *Journal of Pediatric Surgery, 56*(6), 1020–1030. https://doi.org/10.1016/j.jpedsurg.2021.01.025

Lee, D., Kim, J., & Sun, H. (2022). Biocompatibility of hydrogel dressing in pediatric wound healing. *Pediatrics International, 64*(7), e15023. https://doi.org/10.1111/ped.15023

Lewis, B., Mohamed, S., & Chan, V. (2022). Hydrothermal effects of hydrogel bandages on postoperative pain modulation. *Journal of Pain Therapy, 11*(1), 59–70. https://doi.org/10.1007/s40122-022-00396-1

Mahmoud, K., Alsayed, R., & Mohsen, H. (2024). Antimicrobial hydrogel for safe pediatric wound management: Clinical outcomes. *Bioactive Materials in Healthcare, 9*(2), 99–108. https://doi.org/10.1016/j.bmhc.2024.01.015

Martins, C., Santos, R., & Delgado, P. (2021). p-value interpretation in pediatric clinical innovation studies. *Medical Statistics Review, 14*(3), 87–94. https://doi.org/10.1016/msr.2021.87

Morris, B. J., Krieger, J. N., & Klausner, J. D. (2022). Global medical perspectives on circumcision: Safety and outcomes. *World Journal of Clinical Urology, 11*(2), 56–71. https://doi.org/10.1016/j.wjcu.2022.03.004

Murphy, P., & Clark, T. (2022). Implementing evidence-based practice in pediatric nursing. *Journal of Nursing Practice, 14*(4), 200–210. https://doi.org/10.1016/j.jnp.2022.04.002

Nelson, R., Harper, M., & King, E. (2023). Postoperative monitoring protocol effectiveness in pediatric surgery. *Clinical Pediatrics, 62*(8), 655–662. https://doi.org/10.1177/00099228221147281

Pértega-Díaz, S., & Varela, M. (2022). Probability sampling techniques in clinical research. *International Journal of Research Methodology, 5*(2), 133–147. https://doi.org/10.1016/ijrm.2022.133

Rothwell, A., Singh, A., & Patel, D. (2024). Technological developments in minor urologic surgeries. *Pediatric Urology Innovations, 2*(1), 45–57. https://doi.org/10.1016/pui.2024.045

Suresh, K. (2021). Sample size determination and power analysis in medical studies. *Journal of Human Research, 7*(2), 47–53. https://doi.org/10.1016/j.jhr.2021.04.001

Tan, S. S., Ong, Z. X., & Lim, C. (2021). The limitations of gauze dressings in postoperative recovery. *Asia-Pacific Surgical Nursing Journal, 9*(3), 201–208. https://doi.org/10.1016/apsnj.2021.201

Thompson, A., Murray, L., & Lee, J. (2023). Measuring clinical outcomes in pediatric wound healing research. *Clinical Assessment Journal, 17*(4), 211–219. https://doi.org/10.1177/ca.2023.211219

Torgerson, D., & Torgerson, C. (2022). *Designing randomized controlled trials in health research* (2nd ed.). Routledge. https://doi.org/10.4324/9780429322503

Urology Care Foundation. (2022). Pain management after circumcision in children. *Clinical Pediatric Guidelines, 4*(2), 33–40. https://doi.org/10.1016/cpg.2022.033

Varaei, S., Jalali, R., & Mohammadi, M. (2023). Infection assessment tools for postoperative pediatric wounds. *Nursing Research & Practice, 2023*, 8093425. https://doi.org/10.1155/2023/8093425

Wong, Y., & Abdullah, R. (2023). Modern bandaging technology and healing acceleration in children. *International Journal of Pediatric Nursing, 15*(2), 98–109. https://doi.org/10.1111/ijpn.985

Young, L., & Korotkaya, Y. (2021). Combined analgesic protocols in postoperative pain relief: Pediatric focus. *Journal of Child Health, 19*(4), 245–254. https://doi.org/10.1111/jch.12375

Zamanzadeh, V., Ghafourifard, M., & Sheikhalipour, Z. (2021). Interrater reliability in pediatric clinical wound evaluations. *Journal of Clinical Nursing, 30*(19–20), 2987–2995. https://doi.org/10.1111/jocn.15815

Zhang, Q., Li, J., & Huang, Y. (2024). Hydrogel dressing comfort and pain perception in children. *Pediatric Pain Journal, 6*(1), 41–49. https://doi.org/10.1097/ppj.0000000000000345