Development of an evidence-based protocol for care of pilonidal sinus wounds healing by secondary intent using a modified reactive Delphi procedure. Part one: the literature review*

Connie L Harris, Samantha Holloway

ABSTRACT

This article is in two parts. The overall aim of this section was to review the literature in relation to pilonidal sinus wounds (PSW) healing by secondary intent for a Master’s of Science in Wound Healing and Tissue Repair thesis. The purpose of the literature review was to determine if an evidence-based guideline or consensus document existed for the care of these wounds, and if not, to determine the topics from which to develop items for the first round of a modified reactive Delphi questionnaire. Part two will describe the iterative process, the analysis and the results. The review found no best practice guidelines concerning PSW, and only one clinical pathway. Seventeen areas of interest were identified that may contribute to optimal healing conditions or to delayed healing. These included microbiology of infected PSW, signs and symptoms of localised or deeper (spreading) chronic wound infection, swab for c&s, role of topical antiseptics or antimicrobials, systemic antibiotics, local wound interventions, optimal positioning, wound cleansing, principles of moist wound healing/dressing selection, topical negative pressure (TNP) therapy, peri-wound skin decontamination and depilation, pain control, physical activities, optimal nutrition and patient education.

Key words: Consensus • Items affecting healing • Pilonidal sinus disease • Pilonidal sinus wounds

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INTRODUCTION
Sacrococcygeal pilonidal sinus disease (PSD) is an acquired condition caused by one or more factors. One theory suggests that body hairs entering hair follicles in the natal cleft cause a foreign-body reaction (1,2). It has also been postulated that tips of hairs and debris penetrating the dermis in existing midline pits or site of previous excision were the cause (3), while others described keratin plugs in hair follicles causing folliculitis and gradually abscessing into the subcutaneous tissue, forming holes or pits (2,4).

The onset of PSD occurs between puberty and the age of 40 (5,6) with an acute abscess with pain, pus and swelling in the natal cleft or lower back. Surgical intervention for the acute abscess is usually incision, drainage and curettage, treated with oral antibiotics and packing of the wound until healed. This has a 40–60% recurrence rate (7,8). Chronic PSD includes painful single or plural discharging sinuses and tracks (9). Wide excision and primary or secondary closure is required for chronic or recurrent sinus (6). Primary closure includes interventions such as incision and closure along the natal cleft line, or more complex Bascom’s or rotational flaps or Z-Plasty, designed to change the contour of the natal cleft. Incisions and primary closure have a recurrence rate of 37% (10), while complex surgical procedures carried out in specialised health care facilities, have smaller recurrence rates (7.3–9.6% and 0–2%, respectively) (10). Healing by secondary intention is associated with longer healing rates (2–6 months), often requiring daily nursing visits, with recurrence rates between 8 and 43% (6,10). However, many health care professionals dealing with pilonidal sinus wounds (PSW) know of situations where healing has taken 1–2 years or more.

Post-operative PSW include simple incision and drainage sites, open excisions left to heal by secondary intention (Figure 1), or failed primary closure with dehiscence. In acute surgical incisions, inflammation occurs a few millimetres beyond the incision, resolving within 3–5 days (11). The incision then progresses through the proliferation and epithelialisation stages in an orderly manner (12). Chronic wounds characteristically contain non resolving inflammation, thought to be a key factor in the non healing wound (13). Debate continues as to whether surgical wounds are acute or chronic in nature, or at what point the cells switch from acute to chronic inflammation, including the opinion that a surgical wound not healed within 5 days is a chronic wound (14). There may be some histological support for this opinion. In a small study to determine the effect of a zinc-based dressing versus a placebo, researchers examined the excised edges and excised tissue of PSW at time of surgery, and repeated punch biopsies of the adjacent tissue, the wound edges and the wound centre at 7 days post-op (n = 64) (15). The histopathology reports of wound edges of individuals in both arms of the study, showed an increase in acute inflammation in 11·1% (zinc) and 28% (placebo) of individuals at the time of surgery, increasing to 81% and 93% on day 7. Chronic inflammation showed little change from 88·8% (zinc) and 72% (placebo) on day 0 to 81% and 87% on day 7. This suggests that PSW have inflammatory elements of both acute and chronic wounds simultaneously.

The usual physician-ordered PSW dressing is either daily 0·9% normal saline dampened gauze dressings and dry dressing or TNP therapy. In the absence of any PSW best practice guideline or ‘gold standard’ there is no clear direction of what will promote healing.

Key Points
- In the absence of any pilonidal sinus wound best practice guideline or ‘gold standard’, there is no clear direction of what will promote healing.
- A thorough literature review performed by the researcher is an important first step in a modified reactive Delphi process.
- It appears that the factors that promote or delay healing in pilonidal sinus wounds are multifactorial, and involve more than the choice of dressing post-operatively.

Figure 1. Pilonidal sinus wound healing by secondary intention (© Connie Harris).
intimacy and social life, pain, recurrent infection and fear of wound deterioration, all contributing negatively to quality of life (17–19).

MATERIALS AND METHODS
The purpose of the literature review was to determine if a best practice guideline or consensus document existed for the care of PSW, and if not, to synthesise existing information to generate the questions for the first round of a modified Delphi questionnaire. The literature review included articles up to 2008, the date of submission for the Master’s thesis. The experiential knowledge and clinical observation of the researcher (20) and an early review of overview articles (1–4,6,8–10) and of a clinical pathway (10) helped to identify the areas of care thought to negatively or positively influence the healing of post-operative PSW. Searches of PubMed, OVID, MEDLINE and Cochrane were undertaken. The MESH terms ‘pilonidal sinus AND wound care’, ‘pilonidal sinus AND dressings’, ‘pilonidal sinus AND RCTs’, ‘surgical wounds AND dressings’, ‘wound bed preparation’, ‘moist wound healing’, ‘antimicrobials AND wound healing’, ‘infected wounds’ and ‘pilonidal sinus wounds AND Sitz baths’ were selected. No alternate search terms for pilonidal sinus were used. This yielded over 200 articles that provided additional citations. Further topic searches in response to expert recommendations or questions from Delphi participants included ‘silver nitrate AND Hypergranulation’, ‘calcium alginate AND haemostasis’, ‘Chlorhexidine AND skin cleansing’ and ‘Chlorhexidine AND wounds’. Very few of these articles were gold standard randomised controlled trials (RCT). Many represented case studies or expert opinion overviews. Although this was not intended to be a systematic review, it was important that an acceptable method of critical appraisal of the quality of the documents be used before data were extracted to form the basis of the Delphi questionnaire. The levels of evidence used by the Registered Nurses Association of Ontario as part of their Nursing Best Practice Guideline series (21) were used (Table 1). These were chosen because they were familiar to health care professionals working in the Province of Ontario, where this study occurred.

RESULTS
The one published clinical pathway (10) included several indicators and interventions that were also mentioned frequently in the ‘opinion’ or overview articles (1–4,6,8,9): infection, friable tissue, pain, exudate, local treatment including the use of silver nitrate and cautery, good wound toilet, choice of dressings and oral antibiotics. Additional articles placed emphasis on shaving the peri-wound skin, hygiene, sources of contamination and level of physical activity. This created 17 topic areas supported by a minimum of 2 articles and a maximum of 19, with varying levels of evidence (Table 2). Please note that literature pertinent to the subject area published since 2008 appears in the discussion in the second section of this paper.

DISCUSSION
The high-level evidence found to support specific interventions with PSW or perianal wounds was limited to the choice of a foam wound dressing (80), debunking the practice of sitz bathing (58) and the apparent benefit of oral zinc supplements (113). The polymicrobial nature of PSW is emphasised in more

Table 1 Registered Nurses Association of Ontario interpretation of evidence

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<th>Level of evidence</th>
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<tr>
<td>Ia</td>
<td>Evidence obtained from meta-analysis or systematic review of randomised controlled trials</td>
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<tr>
<td>Ib</td>
<td>Evidence obtained from at least one randomised controlled trial</td>
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<td>IIa</td>
<td>Evidence obtained from at least one well-designed controlled study without randomisation</td>
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<tr>
<td>IIb</td>
<td>Evidence obtained from at least one other type of well-designed quasi-experimental study without randomisation</td>
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<td>III</td>
<td>Evidence obtained from well-designed non experimental descriptive studies, such as comparative studies, correlation and case-studies</td>
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<td>IV</td>
<td>Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities</td>
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Table 2  Topic areas, references and highest level of evidence for each topic

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<tr>
<th>Topic</th>
<th>Supporting references</th>
<th>Highest level of evidence</th>
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<tr>
<td>Microbiology of infected pilonidal sinus wounds</td>
<td>(22,23–25)</td>
<td>IIB</td>
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<td>Validity of signs and symptoms of localised and deeper/spreading wound infection</td>
<td>(24,26–36)</td>
<td>IIB</td>
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<td>Action based on signs and symptoms of localised and deeper/spreading wound infection</td>
<td>(25,26,37–40)</td>
<td>IIB</td>
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<tr>
<td>Antimicrobial usage for PSW: topical antiseptics/antimicrobials</td>
<td>(40–47)</td>
<td>IIB</td>
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<tr>
<td>Antimicrobial usage for PSW: systemic antibiotics</td>
<td>(10,24)</td>
<td>IV</td>
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<td>Local wound interventions</td>
<td>(6,10,24,48–53)</td>
<td>IV</td>
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<tr>
<td>Optimal positioning for wound assessment and care</td>
<td>(6,54)</td>
<td>IV</td>
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<tr>
<td>Wound cleansing</td>
<td>(23,44,55–64)</td>
<td>IA</td>
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<tr>
<td>Principles of moist wound healing</td>
<td>(24,26,65–81)</td>
<td>IA</td>
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<td>Topical negative pressure therapy</td>
<td>(82–89)</td>
<td>IA</td>
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<tr>
<td>Peri-wound skin care</td>
<td>(23,56,90)</td>
<td>IB</td>
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<td>Removal of peri-wound hair</td>
<td>(6,91–97)</td>
<td>IV</td>
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<td>Wound pain</td>
<td>(98–100)</td>
<td>IV</td>
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<tr>
<td>Physical activities with PSW</td>
<td>(1,56,94)</td>
<td>IV</td>
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<tr>
<td>Nutrition and wound healing</td>
<td>(6,101–110)</td>
<td>IB</td>
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<tr>
<td>Education about personal hygiene</td>
<td>(5,56,90)</td>
<td>IIA</td>
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<tr>
<td>Obesity</td>
<td>(56,111,112)</td>
<td>IIA</td>
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PSW, pilonidal sinus wounds.

than one study (22,23,25). Authors had many opinions regarding recommendations to support healing, and causes of delayed healing or recurrence of pilonidal sinus wounds. Interventions identified from those types of articles were assigned a level IV evidence, for ‘information obtained from expert committee reports or opinions and/or clinical experiences of respected authorities’ (21). Table 3 contains a summary and discussion of findings from the literature.

CONCLUSION
The desire to improve care and thus, theoretically, to improve outcomes for this patient population served as an incentive for this Master’s Thesis research project. Patients who receive evidence-based nursing care achieve 28% improved outcomes in behavioural knowledge, physiological and psychosocial domains, compared to those who do not (121). Successful healing or conversely, failure to heal may depend on which interventions are applied, and in response to what assessment criteria or triggers. Without ‘gold-standard’ evidence, it is difficult to determine which factors are important for healing. Many activities and recommendations currently used with PSW, such as wound cleansing and limitation of physical activities, also do not have research specific to PSW care. There appear to be multiple factors that promote or delay healing in pilonidal sinus wounds, involving more variables than the type of dressing selected. Part Two of this article concerning this thesis project describes...
Table 3 Summary and discussion of literature review findings

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<th>Topic</th>
<th>Summary and discussion of literature review findings</th>
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<tr>
<td>Microbiology of infected pilonidal sinus wounds</td>
<td>The PSW in the natal cleft may be contiguous or lie within a few centimetres of the anal verge, and is often exposed to faecal material containing bacteroides and body hairs, the follicles of which are normally inhabited by anaerobes and Gram-positive cocci, increasing risk for late secondary contamination and infections. A formula to predict a ‘normal’ healing rate for pilonidal sinuses showed statistically significant longer healing times in wounds containing mixed aerobic and anaerobic bacteria. This was later used to substantiate the deleterious effect of heavy anaerobic load on healing in PSW. The researchers found Staphylococcus aureus in 23 PSW, with a statistically significant mean delay in healing of 45.7 days. S. aureus was associated with anaerobic bacteria, suggesting a polymicrobial bacterial load. In a study of excision and primary suture of PSD, researchers reported changes in the bacteria genus pre- to post-surgery, and associated complication rates. Pre-operative anaerobic growth resulted in 79% complications, pre-operative aerobic growth resulted in 40% complications and mixed growth had 52% complications. Gram-negative bacteria became more prominent post-operatively.</td>
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<td>Validity of signs and symptoms of localised and deep infection in chronic wounds</td>
<td>High bacterial counts and/or prolonged inflammation cause increased inflammatory cytokines, increased protease activity and decreased growth factor activity, all of which inhibit wound healing. Agreement about relevant signs and symptoms of infection in PSW should exist between health care professionals, beyond the traditional cardinal signs of infection of redness, warmth, swelling and pain. Additional signs and symptoms of tissue infection include delayed healing, discolouration, friable granulation, pocketing at the base of the wound, bridging of the epithelium or soft tissue, abnormal smell and wound breakdown. To validate some of these S&amp;S researchers developed a checklist of 12 clinical S&amp;S of the infection. A panel of six wound experts provided initial content validation, excluding ‘bridging of epithelial tissue’. They tested the reliability with chronic wounds, which included surgical wounds. All symptoms had almost perfect agreement, and although pocketing in the base did not occur in the examined wounds, 100% of experts supported this item. To further test these S&amp;S, a second group performed quantitative cultures obtained by tissue biopsy to determine validity, using four parameters: Sensitivity: the proportion of wounds with the symptom who truly have the disorder. Specificity: the proportion of wounds without the symptom who truly do not have an infection. Positive predictive value: the proportion with positive test results who are correctly diagnosed. Likelihood ratio: the relative probability that the target disorder is present. Red friable granulation tissue, smell or increasing foul odour, increased pain or size or wound breakdown had validity in all four parameters. Increased serous exudate and oedema showed validity in the likelihood ratio, sensitivity and specificity. Delayed healing and increased peri-wound temperature showed validity in sensitivity and likelihood ratio. Debris or discolouration of the wound bed had validity in the likelihood ratio. Purulent exudate and peri-wound erythema showed validity in specificity. The mnemonics ‘NERDS’ and ‘STONES’ classify the S&amp;S of localised and deeper or spreading infection. S&amp;S of localised infection (NERDS) include non healing, exudate increased, red friable tissue (caused by damage to the structure of the collagen matrix and increased blood vessels in the tissue), debris or discolouration of the wound bed: dark, dull red or grey green, raw, red or salmon colouration with gelatinous texture and smell. Spreading infections S&amp;S (STONES) include size, temperature, osteomyelitis, new areas of satellite breakdown (beyond the original wound) and/or recurrence of wounds within a short period of time, erythema and smell.</td>
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Friable granulation tissue has been noted in the presence of haemolytic streptococci and anaerobic bacteria, with a statistically significant ($P = 0.02$ and $< 0.001$) correlation between a pocket in the base of the PSW, bridging of the epithelium and infection (30). This was explored as a marker of infection in acute surgical wounds (33), and further validated in a Delphi technique ($n = 10$) (27). PSWs that may appear to be healing at the distal and proximal ends, or already closed, can develop small pinhole openings in the newly epithelialised tissue. These may probe to the main wound or be isolated and contain friable granulation tissue. Pocking in pilonidal wounds not treated with antibiotics has a statistical significance due to the formulation of deficient granulation tissue where pockets of infection may form ($P = 0.02$, 24, 25). Superficial bridging of the granulation or epithelial tissue formed in the presence of bacteria contributes to breakdown with only minor tension on the tissue. The fragile epithelium is bluish in colour (28) (Figure 2). Levels of evidence were I to IV.

Although extremely rare in PSW, osteomyelitis is included in the differential diagnosis for PSD by the American Society of Colon and Rectal Surgeons (34) and one fatal PSW complication of osteomyelitis 3 weeks post-surgery has been reported (35). Osteomyelitis develops secondary to a contiguous focus of polymicrobial infection. The organisms may be spread by nosocomial contamination during peri-operative or intra-operative procedures, or extend from an adjacent soft tissue infection (36) (level of evidence III).

The gold standard for quantifying bacteria in wounds are tissue biopsies (37), but are not practical in the community setting due to high cost and limited accessibility. Fortunately, a linear relationship between quantitative tissue biopsy and swab for culture taken using a specific method of sampling has been validated (38). This is the recommended technique for assessing any open wound (25, 37, 39) (level of evidence IIb). Swabs for culture and sensitivity (C&S) are important in determining the type of bacteria and the sensitivities to antimicrobials, but are not necessary to confirm the presence or absence of infection. The C&S results may not reflect the presence or absence of biofilm. Performing a swab for C&S is supported in the wound bed preparation paradigm which includes the recommendation to ‘treat the cause’ (26). The presence of three or more of the signs and symptoms of localised wound infection (NERDS) was thought to indicate that the patient requires topical antimicrobial therapy such as antimicrobial (antiseptic) dressings or antibiotic creams/ointments (40). For three or more symptoms of deeper or spreading infection (STONES), systemic antibiotics were recommended (level IV). The goal of using topical antimicrobials is to lower bacterial counts (26).

Chronic wounds most appropriate for topical antiseptic/antibiotic treatment are those heavily contaminated with multi-microorganisms and failing to heal (40). Commonly used topical antiseptic agents include iodine-releasing dressings, chlorhexidine, and silver dressings, which provide high concentrations locally, avoid systemic allergic reactions and do not disturb the normal commensal microflora or contribute to induced resistance (41).

In a systematic review of antimicrobials for chronic wounds, three clinical trials involved PSW (42). In the first, gentamicin-impregnated collagen plus a pressure dressing had significantly faster healing ($P < 0.001$), but the reviewers could not distinguish whether it was the gentamicin, the collagen or, although not mentioned, the pressure dressing. The second trial involved chlorhexidine 0.5% aqueous solution soaked gauze versus a silicone plastic foam dressing, which had no significant difference in healing times. However, this strength of chlorhexidine would have some tissue toxicity (43), so while dealing with bacterial load, it may have delayed healing. The third trial involved eusol 0.5% (sodium hypochlorite), which is also toxic to tissue cells (44), and the difference in healing times had no significance.

Cadexomer iodine (CI) and silver (AG) are broad-spectrum antimicrobials with desirable benefits (44), but no RCTs examined their use with PSW. CI removed chronic inflammatory substances, pus and debris, reduced pain, erythema and the bacterial count while stimulating granulation formation in chronic venous ulcers (45). It causes an acceleration of healing in chronic human wounds compared to povidone (iodine) (42), and the beneficial role of CI in enhancing acute inflammation and angiogenesis has been shown in vitro (46). One poster presentation documented the beneficial effect on healing in PSW (47). Silver dressings lack toxicity and are thought to decrease inflammation (58), release therapeutic levels of silver within a short time and remain active in the dressing for a period of 3–7 days, depending on the product and level of exudate (level of evidence IV).
Antimicrobial use for PSW: systemic antibiotics

In a prospective, non randomised, longitudinal study, patients with PSW healing by secondary intention received three different treatments: (i) no antibiotic therapy, (ii) antibiotics started between 7 and 14 days post-operatively to alternate patients and (iii) antibiotics as needed based on the 'unhealthy' appearance of the wound (24). Patients with PSW treated with metronidazole 400 mg tid for 2–4 weeks had statistically significant \( P < 0.001 \) faster healing than those without antibiotics. Those in the third group having haemolytic streptococci were also given erythromycin 250 mg qid (level of evidence IIb). A published clinical pathway for infected pilonidal sinus wounds includes metronidazole 400 mg tid plus erythromycin 250 mg qid × 2 weeks (10). If no wound improvement is seen after the 2-week course, the antibiotics are continued.

Local wound interventions

Delayed wound healing in PSW is due to a number of factors. These may include:

1. Localised infection in PSW causing superficial undermining/pocketing in the base and premature bridging of granulation or epithelium (6,24).
2. Friable granulation tissue, also described as moist, exuberant hypergranulation (48), caused by excessive production of inflammatory growth factors in response to chronic localised infection, moisture or friction (49).
3. Epithelial migration is prevented or delayed over the hypergranulation tissue (50), and will be unstable with poor tensile strength.

In a previously published pathway for PSW care (10), specific interventions such as the use of silver nitrate (AgNO₃) are included, but there is no mention of improved clinical outcomes such as reduction of bacterial load, decreased volume of exudate or friable granulation tissue, or faster healing times compared to a control group. There were no published studies regarding the efficacy of treating friable granulation tissue or the consequences of allowing it to persist in PSW. AgNO₃ removes unwanted tissue with a caustic activity, causing a temporary stinging discomfort. Rapid release of excess cellular fluid occurs, reducing volume in the oedematous tissue (51). AgNO₃ is contained to the area of application and converts to inert silver and other compounds. It eventually sheds by desquamation. The pathway also advocates opening the undermined area with a scalpel blade after local anaesthetic (10), although in practice, simply spreading the buttocks apart may deliver enough force to split the newly formed superficial bridge open, with no noticeable discomfort to the individual. AgNO₃ sticks and a calcium alginate dressing applied for 24 hours will promote haemostasis (10). Alginate fibres left behind will gradually break down into calcium and simple sugars, and should not cause a foreign body reaction. Ongoing use of alginates may initiate a desirable acute inflammatory response and manage hypergranulation tissue (52,53). Prompt attention to undesirable changes in granulation and epithelial tissue may be critical to promoting healing in PSW (level of evidence IV). If discomfort is anticipated during the application of AgNO₃, analgesia should be taken prior to the application.

Optimal positioning for PSW care

The removal of embedded hair and any debris at every wound inspection is important to healing (6). It is recommended that the optimal position for visualisation of the anal/perianal area (applicable to a PSW in the natal cleft) is a ‘prone jack-knife’ position (54), but this may be impossible to create in the home-care setting. Creating a modified ‘jack-knife’ position with the individual lying prone with one or two pillows under the anterior pelvis allows the buttocks to be easily spread or taped to optimise exposure of the wound bed (level of evidence IV). This positioning should not cause discomfort to the individual, and because it enhances visualisation and care, should allow for a shorter treatment time per intervention. If the individual is allowed to lay on their side, the buttocks may be tensed, which prevents complete visualisation of the wound bed, challenging a single care provider to perform a careful wound assessment, identify changes to the wound tissue including bridging and pocketing, remove migratory hairs, prepare the peri-wound skin, cleanse and apply dressings.
Literature review on care of pilonidal sinus wounds

Wound cleansing

Routine wound cleansing has been described as being ritualistic, not evidence-based (55), but PSW are prone to faecal and foreign body contamination including debris and hair causing late secondary infections (2,5,23,24). The post-puberty sex hormonal influence on the surrounding hair follicles means that they normally contain anaerobic bacteria and Gram-positive cocci, and predisposes them to inflammation (56,23). Traditional cleansing for PSW has involved the use of showering or sitz-bathing (soaking the perineal area in a tub or basin of water). In a pooled systematic review of five RCTs comparing showering to non showering for postoperative wounds, the rate of healing, infection or dehiscence was unchanged although improved morale was noted (57). In a review of 36 published articles outlining the physiology, risks, benefits, complications and techniques of sitz baths used in anorectal/gynaecological disorders, there was lack of RCTs supporting sitz baths to promote faster healing or fewer complications (58). Although PSW were not included, they occur within centimetres or contiguous with the anal verge, and it seems reasonable to assume that the same results would apply. Benefits may include improved peri-anal hygiene and relief of discomfort, but they do not negate the need for effective PSW cleansing. Conversely, the authors reported that immersing parts of the body in a tub of water could cause systemic vasodilatation, decreasing the circulation to the perineal area, theoretically delaying healing. The level of evidence NOT supporting the use of sitz baths or showering as means of wound cleansing is Ia.

Practitioners must then consider what wound cleansing method (technique and solution) is most effective. Swabbing a wound redistributes bacteria (59), traumatises new granulation tissue (60) and sheds fibres (50). Flushing or irrigating bacteria-inoculated rabbit wounds with 150 cc of normal saline delivered at 7–12 pounds per square inch (psi) effectively removed surface bacteria, debris and chronic wound exudate, but higher pressures (such as with hand-held showers) forced surface bacteria and debris deeper into the wound with deleterious effects (61). A systematic review of three RCTs and one comparative study examining a pressure of 8–13 psi for cleansing full thickness lacerations and traumatic wounds showed decreased levels of bacteria and inflammation (57) (level of evidence IIb).

The use of isotonic ‘normal saline’, which does not alter the viability of the key cells involved in wound repair (62) versus water, which is not isotonic and is less desirable for wound cleansing, continues to be debated (44). Cleansing with room temperature saline compared to 37°C tap water was associated with a higher infection rate for the saline at room temperature (10.3%) versus the heated tap water (5.4% infection rate) (63), with a possible linkage of colder solutions and increased infection. However, the RCT was methodologically flawed due to the different temperatures between the solutions (level of evidence Ib). A 3-hour delay of mitotic activity and inhibition of leukocytes with a 40 minute drop in wound temperature was also reported following wound cleansing (n = 420), but the lack of descriptive methodology regarding temperature or volume of the cleansing solution diminished the reliability and validity of the study (64).

Principles of moist wound healing

Many physicians and surgeons tend to order normal saline wet to dry gauze dressings covered with a bulky dressing as the ‘traditional’ choice for PSW care. Since Dr George Winter (65) showed faster epithelialisation in a small sample of experimental porcine wounds covered with an occlusive dressing, and angiogenesis and revascularisation were enhanced in wounds that had a moist environment compared to those that were allowed to dry out (66), the principles of moist wound healing have evolved into a science. However, the evidence to support currently available, specific dressing choices for PSW is poor. Ideal dressings for healing provide moist, isotonic, interactive and non toxic environments, but only function optimally when they match the characteristics of the wound (26,67). The ideal characteristics of a dressing include:

1. Impermeable to water and bacteria
2. Freedom from particulate matter
3. Thermal insulation
4. Prevention of trauma on removal
Table 3 (Continued)

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<thead>
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<th>Topic</th>
<th>Summary and discussion of literature review findings</th>
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<tr>
<td>5. Removal of toxic substances</td>
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<td>6. Prevention of dehydration</td>
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<td>7. Allowance for gaseous exchange</td>
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<tr>
<td>8. Absorption and retention of exudate to prevent maceration, leakage and increased risk of infection</td>
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"Traditional" gauze dressings only meet characteristic no. 7 (70). In a reproducible study, Staphylococcus epidermidis migrated through five layers of moist gauze in less than 30 seconds when the moist gauze was placed on uncoated paper wrappers on a contaminated agar plate ($p = 0.0495$) (71). In a 30 year retrospective review of clinical infections in wounds healing by secondary intent, a 7.1% infection rate with gauze versus 1.3% with occlusive dressings was identified (72), while in a review of 50 controlled trials for conventional and occlusive dressings, a statistically significant infection rate as much as 50% lower ($P < 0.001$) for the occlusive dressings than gauze dressings was reported (73). All three papers suggest an increased risk of infection with gauze dressings where strike-through of exudate and external contamination easily occur (level of evidence Ib). Macromolecular fragments shed from gauze dressings are visible to the human eye, but not smaller microscopic particles. An animal study suggested a relationship between shed gauze particles from lint, left behind at the time of surgery, and the formation of foreign body granulomas, mostly inflammatory histiocytes and adhesions (74). A statistically significant ($P = 0.012$) difference in the presence of inflammation and foreign body reaction was noted in a second small prospective study ($n = 15$), comparing surgical animal wounds dressed with cotton gauze versus those with no dressing (75) (level of evidence Ib). Porous gauze adheres to the wound being non selective and painfully removes healthy tissue along with non viable in the wound bed (76). In a large survey of 11 countries and 3918 respondents, the European Wound Management Association identified pain-free removal as the most highly desired dressing characteristic, while gauze topped the list as the dressing associated with the most pain (77) (level of evidence IV). Normal saline wet-to-dry gauze allows wound cooling to temperatures of 21° to 27°C, 10° below the optimal 37°C temperature for cellular activity (67) (level of evidence IV). A reduction of temperature due to water’s high heat of vaporisation (540 cal/g), results in sub-optimal temperatures for cellular activity. In a small study examining foam dressings moistened with normal saline over a wound versus an identical dry foam dressing applied over intact skin ($n = 10$), researchers hypothesised that as the water evaporates, sodium and chloride concentrations become hypertonic, providing an osmotic gradient for absorption of wound fluid (78). The controls showed a rise in osmolarity and sodium chloride concentration in the absence of wound fluid. The wound dressings retained isotonicity over 6 hours with absorption of wound fluid, at which time the testing ceased. An adherent layer of blood and proteins on the dressing usually prevented further transfer of fluid and electrolytes from the wound into the dressing, completely dehydrating and dessicating the dressing. They recommended ‘frequent’ (q6h) dressing changes, to maintain isotonicity and permeability, but in a time of nursing shortages and fiscal restraints, this creates a burden to the health system (level of evidence III).

Although an advanced dressing may cost more than 10 times that of gauze, the associated costs with gauze being changed twice daily are almost five times that of the advanced wound product (70,79). In a study using excised porcine flank wounds and transparent, semi-occlusive transparent film dressings, it was shown quantitatively that revascularisation was enhanced in wounds with a moist environment, compared to those that desiccate when covered with gauze ($P < 0.05$) (66). A systematic review including six randomised controlled clinical trials with PSW determined that the trials were of poor quality and small size (80). There was insufficient evidence of any improved healing due to the advanced products (three silicone foam dressings, one hydrocolloid, one calcium alginate: all five used gauze with various solutions as the control, and a sixth compared polyurethane foam versus calcium alginate). However, foam dressings appeared to be the best alternative to gauze, and were preferable due to pain reduction, patient satisfaction and nursing time (level of evidence 1a).
Dressings should manage wound exudate, allowing the proliferation of fibroblasts, keratinocytes and endothelial cells necessary for cellular reproduction, angiogenesis, and to remove debris to maximise the healing activity (81). Optimal moisture balance potentiates epithelial cell migration and prevents desiccation, maceration of the peri-wound skin, leakage and decreases the risk of infection (26) (level of evidence IV).

Dressings that minimise wound bed disruption and cooling, reduce the frequency of the dressing changes, decrease patient discomfort and improve cost-effectiveness are important alternatives to gauze (70). Cost-effectiveness considers the cost of the dressings, nursing time and ancillary supplies such as cleansing, and summarises the cost of achieving the desired outcomes (79).

Desired outcomes for PSW healing by secondary intent include reduction in infection, pain relief, decreased time to healing and improved quality of life. It also seems prudent that the dressing fits well into the natal cleft and be sealed by self-adhesion at the edges or with tape, leaving no gaps near the anal verge to prevent migration of foreign bodies into the wound.

**Topical negative pressure therapy**

There was a lack of level I–III evidence to support the use of topical negative pressure (TNP) therapy with PSW. In Ontario, Canada, the Medical Advisory Secretariat of the Ministry of Health and Long Term Care commissioned a literature review with recommendations regarding use of the TNP device Vacuum Assisted Closure (VAC™) for acute and chronic wounds (82,83). The authors reported a lack of methodological rigour in small, existing RCTs, case studies and retrospective chart reviews. The studies were inconclusive as to treatment effectiveness. Their recommendation was that current best practice for chronic wounds should only include the use of the VAC™ when, after 4 weeks of moist interactive healing, the wound had not reduced in size by at least 30%. There were no recommendations for acute wounds, and the authors classified surgical wounds as chronic (level of evidence Ia).

Existing literature on the use of VAC™ in PSW management up to 2008 consisted of small case studies (n = 1 to 3) (84–86). Making broad assumptions based on one to three cases would only be appropriate if all patients with PSW were identical in risk factors, extent of disease, surgical technique and size of the resultant wound, which they are not.

In one study, the VAC™ was initiated within 24 hours of surgery for adolescents with PSD (n = 21) (87). Sixty-seven percent of the patients were obese while 15 had recurrent disease. Obese patients averaged 62 days to healing, and lean patients averaged 38 days. Those with recurrent disease healed at an average of 48 days, and three developed recurrent disease. Although lacking key information (wound size and bacteriological status), or an attempt to predict what the normal healing time for these wounds would have been (22), the difference in healing between obese and lean patients represents roughly 3 weeks longer healing for obese patients with a treatment that reputedly speeds the rate of healing. It may be that given sheer body size the wounds of the obese individuals were larger than those of their leaner colleagues, which would correlate to longer healing times regardless of the treatment. Large wound sizes or localised infection would both prolong the healing times.

In a retrospective study for complex PSD, VAC™ was applied immediately post-operatively following wide excision (n = 5) (88). Using the prediction of healing equation [the greater of the depth or width equals (50 mm times 1.23 plus 4.3 days)] (22,24), the mean expected healing time would have been 65-8 days. It was actually 84 days. No cost–benefit analysis was undertaken (level of evidence III).

The work on topical negative pressure in wound management by the European Wound Management Association (89) is helpful in determining criteria for implementation and discontinuation of TNP therapy. Treatment objectives that might apply to PSW include:

1. Manage excessive exudate affecting care, skin integrity and quality of life,
2. Promote rapid improvement in wound,
3. Stabilisation of a wound such as a dehisced surgical wound, and
4. Promote healing when it is not progressing with moist interactive dressings,

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Suggested treatment endpoints include:
1. A decrease in exudate levels such that can be managed with moist interactive dressings,
2. 100% granulation tissue up to the surface of the stable, healthy wound, and
3. Wound bed preparation or healing aims managed more cost-effectively with alternative dressing (level of evidence IV).

Peri-wound skin care
Frequent faecal contamination of PSW and dressings occurs due to the proximity to the anus. A paper reporting on meticulous wound and peri-wound skin care for PSW, identified delayed healing in patients who did not comply with the prescribed daily dressing change regime (90), with the thought that soiling of the dressing and wound contributed to the delay. Bacteria found in PSW include bacteroides (23), Staphylococcus, Streptococcus (25), Escherichia coli and Pseudomonas aeruginosa (113). Staphylococcus occurs in the perineal skin in women (114), and would be expected in males who tend to have more abundant body hair, the follicles of which are a nidus for anaerobes and Gram-positive cocci (23).

In two prospective studies examining pre- and post-operative bacteriology samples from pilonidal sinus wounds, a high number of post-operative bacteria differed from pre-operative ones, which they attributed to late secondary contamination and infection \( n = 103 \) (23). No literature described any deliberate attempt to decolonise the PSW peri-wound skin, but support was found for this activity in other types of skin contamination. Chlorhexidine is an antimicrobial cleanser that is effective against common skin bacteria, causes little tissue or clothing damage (a concern in the community sector), is inexpensive and in diluted concentrations is non-toxic (115). It is available in several concentrations and preparations. In a RCT using a 30-second hand wash with 0·5% chlorhexidine versus a 70% alcohol wash, a statistically significant \( P < 0·01 \) 98·2% reduction of bacteria in the chlorhexidine group by day 5 was reported \( n = 160 \) (116). A highly effective in vitro antibacterial activity of cetrimide 0·15% + chlorhexidine 0·015% against Staphylococcus aureus, Streptococcus pyogenes Group A and Enterococcus faecalis within 1 minute and against Pseudomonas aeruginosa and proteus mirabilis with a 5-minute contact has been shown in vitro (117). It causes few skin reactions, and proteins present in wound exudate have minimal action on the effectiveness. The level of evidence for chlorhexidine decontaminating the skin is Ib.

Removal of peri-wound hair
PSW peri-wound hairs trap faeces, bacteria and debris. Hairs protruding into the PSW are a foreign body contributing to chronic inflammation and interfere with wound healing (2,91).

Careful hair removal reduces contaminants and irritation and allows visualisation of the wound bed. The removal of hair is an important strategy in altering the anoxic midline defect conditions and preventing proliferation of anaerobic bacteria (92). No RCTs or cases studies described shaving the peri-wound area, but several authors recommend it. The thought is that diligent removal of the peri-wound hair improves hygiene, removes a source of dead hair shaft infiltrates and reduces moisture in the area that would further inflame hair follicles (93). Recommendations included removing hair:

1. In a 5-cm wide strip extending from the anus to the pre-sacrum (94)
2. 3·5 cm proximally to 2·5 cm distally, but did not describe the lateral extent (95)
3. In the region of the natal cleft (96)
4. From the closely adjacent skin meticulously (97).

Hair removal improves the hygiene of the area, allowing visualisation and removal of any retained hairs or debris (94), and improves the secure adherence of the dressing to the skin. Other recommendations include shaving of the natal cleft, post-healing up to 40 years of age (the upper age limit of when PSD tends to be seen, when a decrease in sexual hormones may result in reduced stimulation of the pilosebaceous glands) (6). A possible causative factor in the development of PSD is enlargement of the hair follicles due to stretching of the follicular...
openings by the gravitational pull of the buttocks with physical activity. If the force is too great, the follicle ruptures (94). The ongoing traction and vacuum forces in the natal cleft will suck keratin and hair into the distended follicle, so diligent removal of hairs will help to prevent recurrence (level of evidence IV).

Education about personal hygiene

Soiling of the dressing and PSW contributed to delay in healing in patients who did not comply with the prescribed daily dressing change regime (90). If this is true, then individuals with PSW who shower or bath without removing their soiled dressing, or miss scheduled dressing changes, are at risk due to poor hygiene. Poor hygiene may contribute to a natal cleft collection of perspiration, sebaceous material, desquamated epithelial cells and hair and debris from elsewhere in the body (118). It is interesting to note that pilonidal disease is rare in Asia and Africa where routine ablution (washing of the body) occurs after defecation (119). It seems prudent that individuals with healed PSW should take extra care in keeping the natal cleft clean and dry (level of evidence IV).

Obesity

A correlation between obesity and pilonidal sinus incidence was noted in American college students as early as 1953 (1). Others identified obesity as a predisposing factor in PSD (56,111,112), with other factors noted such as male sex, family history, local trauma and sedentary work (56). Although since refuted that obesity is not a direct cause of PSD (120), individuals with a high body mass index (mean of 29-35) had a higher recurrence of PSD following surgical procedures (111). Obesity may contribute to increased friction in the natal cleft, thought to increase the level of inflammation and risk for development of PSD (level of evidence IIa).

Wound pain

Patients with PSW may report pain related to the dressing change, or the inability to sit comfortably (98). Consequently, absences from work or school may negatively influence the quality of life of the individual. Pain is an individualised response wherein two individuals with a PSW of similar size and complexity may report different levels of pain. In a quality of life survey of individuals with acute wounds (n = 80), 62 of which had PSW, 15% reported discomfort, 49% reported disturbed sleep for six or more nights, and 20% reported decreased appetite (due to discomfort) (99). Treatment interventions for managing procedure-related pain should include consideration of the type of the procedure, the anticipated level of pain, and individual factors such as age, emotional and physical conditions for patients of all ages (100). Pain-relieving interventions during dressing change for PSW would include pre-procedural analgesia, and the use of non-pharmacologic interventions such as the use of non-adherent dressings, and warming the cleansing solutions (level of evidence IV).

Physical activities

Physical stress for PSW located in the natal cleft occurs simply with the act of walking (1), where the movement of the buttocks creates a ‘rolling’ effect. Movement of the buttocks creates a ‘cigarette-rolling’ or drilling effect of two flat planes separated by a cleft, suctioning hairs into a bundle along the base, which eventually puncture the skin. This drilling effect also causes friction and chronic inflammation, which may contribute to the exuberant hypergranulation tissue often seen in PSW. The same forces can cause shearing of the fragile healing epithelium. Physicians often advise the patient to decrease their physical activities, due to the fear of shearing of the fragile epithelium during and shortly after healing, or to ‘not sit’, due to reports that long periods of sitting, local trauma or driving in automobiles with uncomfortable seats occurred prior to PSD symptoms being reported (5). However, no RCTs or case studies compared outcomes for physically active PSW patients to those who were more sedentary. One paper described initially limiting activities of armed forces personnel with PSW, avoiding activities like sit-ups and leg-lifts, but later allowed these activities with a small pillow under the natal cleft for cushioning (94) (level of evidence IV).

Nutrition and wound healing

Zinc is important in the inflammatory phase of healing for membrane stability and in the proliferative and remodelling phases for the maturation of collagen (101). Zinc is found in red meat, mushrooms, spinach and dark green vegetables, yogurt, pumpkin and sesame seeds, oysters, shellfish, herring, liver, liver, legumes, milk and wheat bran, among other sources. Deficiency causes decreased fibroplasia, epithelialisation, collagen synthesis and wound strength (102). A RCT in young men with PSW found that oral zinc sulfate (220 mg tid) decreased the time to healing of large pilonidal sinus wounds by a 43%, which was statistically significant (P &lt 0.05) (103) (level of evidence Ib).
The recommended daily allowance of protein for adults is 0.8 g/kg/body weight/day. The presence of a wound increases the body’s need for proteins while as much as 100 g of proteins are lost in wound exudate daily (104). To meet this increased demand created by the wound, the body requires 1.5 to 2 g/day (105). The immune system cells, lymphocytes, leukocytes, phagocytes, monocytes and macrophages are mainly comprised of proteins. They are necessary in order to initiate a healthy inflammatory response in the healing process. Protein is also necessary for cell division and for the synthesis of collagen and growth factors (106,107).

Vitamin C is necessary for optimal immune response, cell mitosis and the migration of monocytes into the wound tissue and transformation into macrophages. It forms bonds between the collagen fibre strands, providing extra stability and strength, and promotes angiogenesis. If these bonds do not occur, the collagen will break down rapidly, due to collagenase, an enzyme found in the extracellular fluid. Vitamin C is found in foods such as parsley, broccoli, bell pepper, strawberries, oranges, lemon juice, papaya, cauliflower, kale, mustard greens and Brussels sprouts (108). Deficiency causes increased capillary fragility, decreased wound strength, wound dehiscence and impaired collagen production. Smokers and individuals with an acute or chronic inflammatory state are at risk of Vitamin C deficiency (106,108). Cigarette smokers should double the necessary daily intake (109).

Even minor surgery raises the basal metabolic rate by up to 10%. The normal or non stressed level is 20 to 25 calories/kg of body weight per day. A draining wound can increase this to 30 to 40 calories/kg/day (105). The Harris–Benedict equation (110) can be used to determine the individual’s needs and takes into account their age, sex, body size, physical activity, surgery, infection and presence of wounds. It is important to remember than obese patients can be malnourished and will not heal well if placed on a weight-reduction program at this time.

No studies specifically examining the role of protein, Vitamin C or Caloric intake in PSW were identified (level of evidence IV).

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Literature review on care of pilonidal sinus wounds

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