**The clinical progression and wound healing rate of dehisced perineal tears healing by secondary intention: A prospective observational study**

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**Abstract**

**Objectives**

To establish the clinical progression of dehisced perineal wounds healing by secondary intention and to investigate the incidence and factors associated with delayed healing.

**Study Design**

Prospective cohort study of women with perineal wound dehiscence referred to a UK dedicated perineal clinic, managed conservatively.

**Methods**

Secondary analysis of women with perineal wound dehiscence recruited into the PERINEAL study between August 2020- August 2021 (NCT 04480684). Three-dimensional wound measurements were taken with the Silhouette® camera. Significant bacterial colonisation was diagnosed using the MolecuLight i:X camera. As it is agreed that acute wounds should heal sufficiently within four weeks, diagnosis of delayed wound healing was made if a wound took longer than four weeks to heal. A wound was deemed to have healed if there was complete wound closure, with no evidence of granulation tissue or signs of infection on clinical examination.

**Results**

55 women with perineal wound dehiscence participated. Wounds took an average of 3 weeks to heal (range 1-16) and 38 (69.1%) wounds healed in ≤ 4 weeks from the first clinical review. 17 (30.9%) wounds had significant bacterial colonisation, identified on bacterial fluorescence imaging.

Women with a wound area of <1.60 cm2 or wound perimeter of <5.57cm had a 70% probability of wound healing in ≤ 4 weeks. 47.1% of wounds with significant bacteria colonisation healed within 4 weeks, in comparison to 78.9% of wounds not colonised (p=0.03). 25.0 % (n=2) of wounds with OASI healed within 4 weeks, in comparison to 76.5% (n=36) of wounds with no OASI (p=0.02). Bacterial fluorescence (OR 0.21 (0.05-0.87)) and OASIs (OR 0.09 (0.01-0.66)) were independent risk factors associated with delayed wound healing. The model including wound area, fluorescence and OASIs had the greatest AUC (0.81, 95% CI 0.67-0.94) indicating the best predictive model.

**Conclusions**

This is the first study to describe healing outcomes of dehisced perineal wounds and factors associated with delayed healing. The study findings will help clinicians counsel women effectively and tailor follow-up care at the first assessment, based on individual risk factors.

**Key words:**

Perineal wound dehiscence, Perineal wound infection, Secondary intention healing, Wound healing, Obstetric anal sphincter injuries

**Main Text**

**1. Introduction:**

Despite approximation of perineal injury sustained at vaginal delivery with sutures, wound dehiscence can occur in up to a quarter of cases (1). It is agreed that acute wounds should heal sufficiently within four weeks (2). Wounds which fail to progress in this time are deemed chronic, and a reassessment of pathology and subsequent care should be undertaken (2). Therefore, in dehisced wounds healing by secondary intention, those that take longer than 4 weeks to heal, possess signs of delayed wound healing. To date, there is no evidence surrounding the time needed for complete perineal wound healing. One randomised controlled trial investigated the healing times of dehisced perineal wounds, comparing to those undergoing early re-suturing and those healing by secondary intention was inadequately powered (3). However, a significant difference was found in the wound healing rates between the two arms by two weeks. Yet, at 6-8 weeks there was no significant difference in wound healing outcomes between either treatment arm, as 97% of all dehisced wounds from the recruited women had healed. This assumed estimation in proposed wound healing time is probably secondary to a lack of evidence surrounding the natural history and clinical progression of dehisced perineal wounds.

Wound dehiscence, and the healing time of perineal wounds are outcomes most feared by women (4,5). Also, women experiencing perineal wound complications, often feel that that they are not assessed appropriately at each review and given insufficient information about their recovery (6). Therefore, the objective of this study was firstly, to establish the clinical progression of dehisced perineal wounds healing by secondary intention and secondly, to investigate the incidence and factors associated with delayed healing (>4 weeks).

**2. Materials and Methods:**

This was a secondary analysis of the Prospective Observational Study Evaluating the Sonographic Appearance of the Anal Sphincter in Women With Perineal Wound Infection Following Vaginal Delivery (PERINEAL Study). The study was approved by the NHS Health Research Authority, London - Surrey Research Ethics Committee (20/LO/0304) and was registered with the clinical trials registry (ClinicalTrials.gov NCT 04480684). The PERINEAL study was conducted between August 2020 and August 2021 at Croydon University Hospital (CUH) and aimed to assess the effect of perineal wound infection on anal sphincter integrity using endoanal (EAUS) and transperineal ultrasound (TPUS). The various outcome measures, inclusion and exclusion criteria are reported in the clinical trials registration (7). Croydon University Hospital is a district general hospital, with a tertiary referral specialist perineal trauma and pelvic floor reconstruction unit (8). Prior to recruitment, women were diagnosed with perineal wound infection if they presented with relevant clinical signs and symptoms, including perineal pain, purulent discharge or wound dehiscence (5).

In addition to EAUS and TPUS, participants in the PERINEAL study with wound dehiscence underwent two further investigations as part of their wound assessment. Firstly, bacterial fluorescence imaging of wounds was performed with the hand-held MolecuLight device (MolecuLight, Toronto, Canada), to assess the presence of wound infection in real-time. Presence of bacterial fluorescence (red or cyan) within a wound suggests a wound is colonised with significant loads of bacteria (>104 CFU/g) (Figure 1) (9,10). Three dimensional (3D) measurements (length, width, depth) of the wound were taken with the Silhouette® camera (Aranz, Christchurch, New Zealand): a non-contact device which uses the laser assisted scanning principle to accurately measure the dimensions of a wound. Surface area, perimeter (total length of the wounds outline) and volume measurements were then calculated using the Silhouette® camera. Horizonal healing rate (HHR) per week: rate of wound edge contracture, was calculated using the Gilman’s equation (11) [(A1-A2)/((P1-P2)/2)]. Vertical healing (VHR): rate of healing from the wound base, per week was calculated using the modified Gilman’s equation described by Kecelj Leskovec et al (12) [(V1-V2)/((A1-A2)/2)] (A=Area, P=Perimeter, V=Volume 1= Beginning of observation period, 2=End of observation period). All investigations were repeated once a week until the wound had healed objectively or up to a maximum of 16 weeks.

All women underwent wound treatment, which included removal of loose suture material and gentle irrigation with sterile water if there was excessive exudate or debris within the wound, to ensure the environment was optimal for wound healing. No local antibiotic or antiseptic treatment were applied to wounds. A wound was deemed to have healed if there was complete wound closure, with no evidence of granulation tissue or signs of infection on clinical examination. Hypergranulation within a wound was treated with silver nitrate. The STROBE guidelines were used to ensure the reporting of this observational study (13).

*2.1 Statistical Analysis:*

Data was analysed using SPSS version 26.0.0.0. The Shapiro-Wilk test was used to assess the normality of continuous variables. Nominal data is expressed as number and percentage. To analyse differences in wounds which healed in ≤4 weeks and >4, Student’s *t* test, the Mann- Whitney U test, Fisher’s exact test or Chi-Squared test were used where appropriate. The multivariate analysis used a logistic regression model which included significant factors identified on univariate analysis. Wound healing analyses were performed using Kaplan-Meir curves to assess the possibility of predicting four-week healing. Logistic curves with the 50% and 70% threshold were constructed using the natural logarithm of the odds of four-week healing. Receiver operating characteristic (ROC) curves were constructed and the area under the curve (AUCs) were calculated with 95% confidence intervals (95%CIs) to investigate the model with the best diagnostic performance. P-values of <0.05 were considered statistically significant. Intra-class correlation coefficients (ICC) were calculated to assess the agreement between length, width and depth measurements take with the naked eye in comparison to the Silhouette® camera. Values of <0.50 indicated poor, 0.50-0.75 moderate, 0.75-0.90 good, and >0.90 excellent reliability (14). Standard errors of measurement (SEM) were calculated to measure the range of error of each measurement.

**3. Results:**

Seventy-seven women with perineal wound infection and dehiscence were approached for recruitment into the PERINEAL study and 55 women (71.4%) agreed to be recruited. Fifty-three (96.4%) women were given broad spectrum antibiotics prior to referral to the perineal clinic and were seen on average 21 days from symptom onset (range 11-46 days). Forty-one (74.5%) women delivered at CUH. Table 1 describes the demographic and delivery characteristics of the 55 women recruited. 8 (14.5%) women had sustained OASIs, of these 3 (37.5%) were diagnosed clinically following vaginal delivery and had an episiotomy. 5 (62.5%) OASIs were missed tears, diagnosed on ultrasound. Of the missed tears, all had an operative vaginal birth and 4 (80%) had a mediolateral episiotomy. Wounds took an average of 3 weeks to heal (range 1-16) and 38 (69.1%) wounds healed in ≤ 4 weeks from first clinical review. Fifty-three (96.4%) of women had a wound swab taken prior to referral to the perineal clinic and 35 (66.0%) had a positive culture. Cultures were polymicrobial in 21 (38.2%) and a single organism in 14 (61.8%). The results of these wound swabs are described in Table 2. Seventeen (30.9%) wounds had significant bacterial colonisation, identified on bacterial fluorescence imaging.

Table 3 describes the demographic and wound characteristics associated with delayed wound healing identified on univariate analysis. Presence of heavy bacterial colonisation and OASI were found to be significantly associated with delayed wound healing. Kaplan Meir analysis showed that 47.1% (n=8) of wounds heavily colonised with bacteria healed within 4 weeks, in comparison to 78.9% (n=30) of wounds not colonised (p=0.03). Also, 25.0 % (n=2) of wounds with an OASI healed within 4 weeks, in comparison to 76.5% (n=36) of wounds with no OASI (p=0.02). Univariate analysis revealed that in comparison to wounds with delayed healing, wounds that healed in ≤4 weeks had a significantly smaller mean initial wound area (1.14 cm2 vs 2.21 cm2), initial wound perimeter (4.88 cm vs 6.67 cm) and HHR per week (0.21 cm/week vs 0.12 cm/week). No significant difference was found with wound volume or the VHR per week. Women with a wound area of <2.70 cm2 had a 50% probability of wound healing in ≤ 4 weeks. Also, women with a wound area of <1.60 cm2 had a 70% probability of wound healing in ≤ 4 weeks. A wound perimeter of <8.84cm had a 50% probability of wound healing in ≤ 4 weeks and a wound perimeter of <5.57cm had a 70% probability of wound healing in ≤ 4 weeks (Figure 2).

The following variables had a p<0.05 on univariate logistic regression and were considered for multivariate logistic regression; wound area (OR 0.49 (95% CI 0.28-0.84)), wound perimeter (OR 0.77 (95%CI 0.61-0.98)), bacterial fluorescence (OR 0.24 (95%CI 0.07-0.81)) and OASIs (OR 0.10 (95% CI 0.02-0.58)). Multivariate logistic regression was performed with wound area and perimeter separately as they are dependent on each other. With wound area in the regression model, OASIs (OR 0.11 (95% CI 0.02-0.77)), were an independent risk factor for delayed wound healing, implying that OASI reduced the odds of wound healing in ≤ 4 weeks by 89%. With wound perimeter in the regression model, bacterial fluorescence (OR 0.21 (95% CI 0.06-0.87)) and (OR 0.09 (95%CI 0.01-0.66)) were independent risk factors associated with delayed wound healing. This indicates that the presence of significant bacterial colonisation within a wound, as evidenced by bacterial fluorescence, and OASI has reduced the odds of wound healing in ≤ 4 weeks by 79% and 91% respectively (Table 4).

ROC curves analysis for the probability of wound healing within 4 weeks for the six wound healing logistic regression models revealed that model 5 (wound area, fluorescence and OASI) had the greatest AUC (0.81, 95% CI 0.67-0.94) indicating the predictive model with the best performance (Table 5).

3D measurements taken using the Silhouette® camera had good agreement with length (ICC 0.82, 95%CI 0.69-0.90) and width (ICC 0.75, 95%CI 0.56-0.85) measurements taken using the naked eye. However, only a fair agreement with depth measurements was found (ICC 0.62, 95%CI 0.32-0.78), with a SEM of ±0.17 cm (Table 6).

**Discussion:**

This study aimed to establish the clinical progression of dehisced perineal wounds and evaluate the incidence of delayed wound healing in dehisced perineal wounds healing by secondary intention, and factors associated with this. We demonstrated that 30% of wounds will exhibit delayed healing. The 50% and 70% probability thresholds associated with wound healing in ≤ 4 weeks for were 2.7 cm2 and 1.6 cm2 for wound area, and 8.8 cm and 5.6 cm for wound perimeter on initial review. Initial wound area, perimeter and significant bacterial colonisation were found to be associated with delayed wound healing rates. We also found that women with OASI exhibited delayed wound healing rates.

The strengths of this study include its originality in assessing the wound healing of dehisced wounds. Women were reviewed weekly until their wound had healed, using accurate 3D measurements, which gave a true representation of wound healing progression. Also, all investigations including measurement and bacterial fluorescence imaging were performed by the same clinician, which reduced the risk of inter-rater variability, therefore ensuring consistency. However, there are limitations of this study. Firstly, the data was collected from a single unit, meaning the results may not be generalisable. Additionally, this study was not powered to evaluate risk factors associated with the healing of dehisced wounds. We also appreciate that the advanced wound imaging devices used in this study may not be available in most clinical settings. However, in comparison to wound swab microbiological analysis, the MolecuLight i:X camera has been shown to have a positive predictive value of 95.4% and negative predictive value of 100% in identifying infected wounds (15). Moreover, we demonstrated that approximating length and width measurements using the naked eye had good agreement with the Silhouette camera. The simplest way of measuring wound area is by multiplying the greatest length by the perpendicular greatest width. However, this does not take into account wound contour and assumes the wound is either square or rectangular. Another simple option, used in other wound types (such as chronic wounds) which allows the appreciation of irregular wound edges, is the use of tracing paper, such as Flexigrid® opsite (Smith and Nephew). Flexigrid® opsite is an adhesive, polyurethane film, which is cross-ruled and can be used to trace wound edges (16). The wound area can then be calculated accurately by counting the squares (1 cm2) within the tracing. Therefore, in a clinical setting, traditional methods typically used to assess wounds including wound swabs and wound measurements at first assessment using the naked eye, could identify women at risk of delayed wound healing.

We acknowledge that the number of women with OASIs in our cohort was small (n=8) and in the majority of cases these tears were missed at delivery and diagnosed on EAUS/TPUS (n=5). However, no study to date has evaluated the effect OASIs on the healing rates of perineal wounds that have dehisced. The small number of women with OASIs in the present study was anticipated, as the median reported rate in the UK is 2.85 % (17). Due to the small sample size, all OASIs (diagnosed and undiagnosed) were combined for analysis. However, we appreciate that when undiagnosed OASIs are compared to OASIs diagnosed at vaginal delivery they are more likely to have poorer outcomes such as a deficient perineum due to disrupted wound healing and atrophy of the perineal muscles adjacent to the anal sphincter (18). Also, as the injured anal sphincter muscles have not been approximated with sutures, wound healing may be further prolonged as the sphincter is left to heal by secondary intention. The process of healing by secondary intention takes longer than primary healing, as filling of the anal sphincter defect with granulation tissue and subsequent wound contraction needs to occur (19). Clinicians should be alerted to the risk of an undiagnosed OASI in perineal wounds which take longer than 4 weeks to heal and consider ultrasound evaluation of the anal sphincter particularly in women with risk factors for OASIs such as operative vaginal birth (20).

With regards to the dimensions of wounds in this study, it is unsurprising that we found that with each unit increase in initial wound area or perimeter on first presentation, the odds of wound healing in ≤4 weeks decreased by 51% and 23% respectively. However, we have demonstrated wound measurements which can be used at first contact, to determine the 70% probability of wound healing within 4 weeks (1.60 cm2 [area] and 5.57cm [perimeter]). Following acute wound injury, there is a rapid increase in wound area until a plateau is reached. Following this, wounds contract rapidly and the length of this stage is directly correlated to the size of the remaining wound area (21). It is also important to note that perimeter directly correlates with wound area (22). This may explain why both wound area and perimeter were associated with perineal wound healing rates. Surprisingly perineal wound depth and subsequent volume measurements were not found to be significantly associated with wound healing rates. However, granulation tissue usually fills the wound bed (vertical healing) and occurs prior to wound contraction (horizontal healing), meaning change in wound volume is likely to be much faster (23).

Moderate to heavy bacterial bioburden indicate significant bacterial loads (>104 CFU/g) and may be associated with wound infection (24,25). In a systematic review evaluating bacterial colonisation and the secondary wound healing of 7178 open surgical wounds, wound healing was found to be 35% less likely in the presence of infection (26). This is in keeping with our study in which we found that the presence of bacterial fluorescence significantly reduced the odds of wound healing in ≤4 weeks by 76%.

In conclusion, this is the first study to describe the wound healing outcomes of dehisced perineal wounds managed conservatively and factors associated with delayed healing. This will help clinicians counsel women effectively and tailor follow-up care at first assessment, based on individual risk factors.

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**References:**

1. Jones K, Webb S, Manresa M, Hodgetts-Morton V, Morris RK. The incidence of wound infection and dehiscence following childbirth-related perineal trauma: A systematic review of the evidence. European Journal of Obstetrics and Gynecology and Reproductive Biology. 2019 Sep 1;240:1–8.

2. Frykberg RG, Banks J. Challenges in the Treatment of Chronic Wounds. Adv Wound Care (New Rochelle). 2015 Sep 1;4(9):560–82.

3. Dudley L, Kettle C, Thomas PW, Ismail KMK. Perineal resuturing versus expectant management following vaginal delivery complicated by a dehisced wound (PREVIEW): a pilot and feasibility randomised controlled trial. BMJ Open. 2017 Feb;7(2):e012766.

4. Perkins E, Tohill S, Kettle C, Bick D, Ismail K. Women’s views of important outcomes following perineal repair. BJOG: An International Journal of Obstetrics & Gynaecology. 2008 Sep;115 (Suppl 1):67–253.

5. Johnson A., Thakar R., Sultan A.H. Obstetric perineal wound infection: Is there underreporting? Brit J Nurs. 2012;21(5 SUPPL.):S28–35.

6. Wiseman O, Rafferty AM, Stockley J, Murrells T, Bick D. Infection and wound breakdown in spontaneous second-degree perineal tears: An exploratory mixed methods study. Birth. 2019 Mar;46(1):80–9.

7. Sultan AH. The Effect of Perineal Wound Infection on the Anal Sphincter. ClinicalTrials.gov Identifier: NCT04480684 [Internet]. ClinicalTrials.gov. 2020 [cited 2021 Nov 8]. Available from: https://clinicaltrials.gov/ct2/show/NCT04480684?term=04480684&draw=2&rank=1

8. Wan OYK, Taithongchai A, Veiga SI, Sultan AH, Thakar R. A one-stop perineal clinic: our eleven-year experience. Int Urogynecol J. 2020 Jul 2;31:2317–26.

9. Rennie MY, Lindvere-Teene L, Tapang K, Linden R. Point-of-care fluorescence imaging predicts the presence of pathogenic bacteria in wounds: a clinical study. Journal of Wound Care. 2017 Aug 2;26(8):452–60.

10. Serena TE, Harrell K, Serena L, Yaakov RA. Real-time bacterial fluorescence imaging accurately identifies wounds with moderate-to-heavy bacterial burden. J Wound Care. 2019 Jun 2;28(6):346–57.

11. Gilman T. Wound Outcomes: The Utility of Surface Measures. The International Journal of Lower Extremity Wounds. 2004 Sep;3(3):125–32.

12. Kecelj Leskovec N, Perme MP, Jezerek M, Mozina J, Pavlovi MD, Lunder T. Initial healing rates as predictive factors of venous ulcer healing: The use of a laser-based three-dimensional ulcer measurement. Wound Repair and Regeneration. 2008 Jul;16(4):507–12.

13. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007 Oct 20;370(9596):1453–7.

14. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. Journal of Chiropractic Medicine. 2016 Jun;15(2):155–63.

15. Hurley CM, McClusky P, Sugrue RM, Clover JA, Kelly JE. Efficacy of a bacterial fluorescence imaging device in an outpatient wound care clinic: a pilot study. J Wound Care. 2019 Jul 2;28(7):438–43.

16. Humbert P, Meaune S, Gharbi T. Wound healing assessment. Phlebolymphology. 2004;47:312–9.

17. Thiagamoorthy G, Johnson A, Thakar R, Sultan AH. National survey of perineal trauma and its subsequent management in the United Kingdom. Int Urogynecol J. 2014 Dec;25(12):1621–7.

18. Taithongchai A, Veiga SI, Sultan AH, Thakar R. The consequences of undiagnosed obstetric anal sphincter injuries (OASIS) following vaginal delivery. International Urogynecology Journal. 2020 Mar 1;31(3):635–41.

19. Singh S, Young A, McNaught C-E. The physiology of wound healing. Surgery (Oxford). 2017 Sep 1;35(9):473–7.

20. McPherson KC, Beggs AD, Sultan AH, Thakar R. Can the risk of obstetric anal sphincter injuries (OASIs) be predicted using a risk-scoring system? BMC Research Notes. 2014 Jul 24;7(1):471.

21. McGrath MH, Simon RH. Wound Geometry and the Kinetics of Wound Contraction. Plastic and Reconstructive Surgery [Internet]. 1983;72(1). Available from: https://journals.lww.com/plasreconsurg/Fulltext/1983/07000/Wound\_Geometry\_and\_the\_Kinetics\_of\_Wound.15.aspx

22. Melhuish. JM, Plassman P, Harding KG. Circumference, area and volume of the healing wound. Journal of Wound Care. 1994 Nov 2;3(8):380–4.

23. Sangwine SJ, Sangwine SJ, Horne REN. Wound Metrics- The background and motivation. In: The Colour Image Processing Handbook [Internet]. Boston, MA: Springer US : Imprint : Springer; 1998 [cited 2020 May 14]. p. 359–60. Available from: http://public.eblib.com/choice/publicfullrecord.aspx?p=3081201

24. Bowler PG, Duerden BI, Armstrong DG. Wound Microbiology and Associated Approaches to Wound Management. Clinical Microbiology Reviews. 2001 Apr 1;14(2):244–69.

25. Copeland-Halperin LR, Kaminsky AJ, Bluefeld N, Miraliakbari R. Sample procurement for cultures of infected wounds: a systematic review. Journal of Wound Care. 2016 Apr;25(Sup4):S4–10.

26. Norman G, Shi C, Westby MJ, Price BL, McBain AJ, Dumville JC, et al. Bacteria and bioburden and healing in complex wounds: A prognostic systematic review. Wound Rep Reg. 2021 May;29(3):466–77.

**Figure Legend:**

**Figure 1: Dehisced perineal wounds exhibiting red fluorescence on bacterial fluorescence imaging within suture material (A,B,C) and the wound bed (D)**

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**Figure 2: Prediction of 4-week healing based on the initial wound area (A) and wound perimeter (B) based on a binary logistic regression model (0=not healed, 1=healed) (orange dashed line=50% threshold, green dashed line=70% threshold)**



**Table 1: Demographics of the study group**

|  |  |
| --- | --- |
| N=55 | **Median (IQR) /n (%)** |
| **BMI (kg/m2)** | 24.8 (20.8-28.1) |
| **Age (years)** | 30 (24-33) |
| **Medical history**  | 9 (16.4) |
| **Smoker** | 5 (9.1) |
| **Mode of delivery** |
| SVD | 35 (63.6) |
| Forceps | 7 (12.7) |
| Ventouse | 8 (14.5) |
| Ventouse + Forceps | 5 (9.1) |
| **1st degree tear**  | 1 (1.8) |
| **2nd degree tear** | 7 (12.7) |
| **Episiotomy** | 47 (85.5) |
| **Obstetric Anal Sphincter Injury**  | 8 (14.5) |
| **Skin suturing technique \*** |
| **Interrupted**  | 8 (14.5) |
| **Subcuticular**  | 20 (36.4) |
| **Suture material** |  |
| **Vicryl Rapide** | 41 (74.5) |
| **Unknown** | 14 (25.5) |
| **Grade of repairer** |
| *Senior House Officer* | 4 (7.3) |
| *Specialist Registrar* | 13 (23.6) |
| *Consultant* | 6 (10.9) |
| *Midwife* | 29 (52.7) |
| *Unknown* | 3 (5.5) |
| **Place of repair** |
| *Delivery room* | 47 (85.5) |
| *Theatre* | 8 (14.5) |

*\* Suturing technique was unknown in 28 women*

*SVD- Spontaneous vaginal delivery*

*N- number*

*IQR- Interquartile range*

|  |  |
| --- | --- |
| **Organisms** | **n(%)\*** |
| **Polymicrobial** n=21(38.2) |
| ***Gram positive cocci*** |
| Staphylococcus spp. | 6 (28.6) |
| Streptococcus spp. | 9 (42.9) |
| Enterococcus spp. | 11 (52.4) |
| ***Gram positive rods*** |
| Corynebacterium spp. | 8 (39.1) |
| ***Gram negative aerobic rods*** |
| Enterobacter spp.  | 1 (4.8) |
| **Gram negative anaerobic rods** |
| Prevotella spp | 2 (9.5) |
| Escherichia spp. | 2 (9.5) |
| Coliforms | 8 (38.1) |
| **Other** |
| Mixed anaerobes | 9 (42.9) |
| **Single organism** n=14(61.8) |
| ***Gram positive cocci*** |
| Staphylococcus spp. | 1 (7.1) |
| Streptococcus spp. | 6 (42.9) |
| Enterococcus spp. | 1 (7.1) |
| ***Gram negative anaerobic rods*** |
| Escherichia spp. | 1 (7.1) |
| Coliforms | 2 (14.2) |
| **Other** |
| Mixed anaerobes | 3 (21.4) |

**Table 2: Bacterial species identified from wound swabs**

\*The denominator is the number of wounds

Spp= Species

**Table 3: Univariate analysis: Demographic and wound characteristics associated with wound healing within 4 weeks**

|  |  |  |  |
| --- | --- | --- | --- |
| **N=55** | **Wounds healed in ≤4 weeks** **(n=38)****n(%)/Mean (SD)/Median(IQR)** | **Wounds healed in >4 weeks****(n=17)****n(%)/Mean (SD)/Median(IQR)** | **p-value** |
| **Patient age** | 28 (5.4) | 30 (4.5) | 0.17\* |
| **BMI** | 25.4 (5.6) | 23.1 (5.4) | 0.16\* |
| **Co-morbidities¶** | 7 (18.4) | 2 (11.8) | 0.71\*\* |
| **No co-morbidities** | 31 (81.6) | 15 (88.2) |
| **Smoking** | 5 (13.2) | 0 (0) | 0.31\*\* |
| **Non-smoker** | 33 (86.8)  | 17 (100.0) |
| **Episiotomy** | 7 (18.4) | 1 (5.9) | 0.22\*\* |
| **No episiotomy** | 31 (81.6) | 16 (84.1) |
| **OASI** | 2 (5.3) | 6 (35.3) | ***0.01\*\**** |
| **No OASI** | 36 (94.7) | 11 (64.7) |
| **Antibiotics** | 36 (94.7) | 16 (94.1) | 1.00\*\* |
| **No antibiotics** | 2 (5.3) | 1 (5.9) |
| **Bacterial fluorescence****(n=17)** | 8 (47.1) | 9 (52.9) | ***0.02\*\*\**** |
| **No bacterial fluorescence****(n=38)** | 30 (78.9) | 8 (21.1) |
| **Days from symptom onset to perineal clinic review (days)** | 15(15-26) | 18 (12-27) | 0.29\*\*\*\* |
| **Initial area****(cm2)** | 1.14 (0.98) | 2.21 (1.51) | ***0.01\**** |
| **Initial perimeter****(cm)** | 4.88 (2.71) | 6.67 (2.33) | ***0.02\**** |
| **Initial volume****(cm3)** | 0.16 (0.47) | 0.36 (0.56) | 0.18\* |
| **HHR****(cm/week)** | 0.21 (0.14) | 0.12 (0.06) | ***0.01\**** |
| **VHR****(cm/week)** | 0.06 (0.09) | 0.03 (0.04) | 0.17\* |

*\*Independent t-test*

*\*\*Fishers exact test*

*\*\*\*Chi-squared test*

*\*\*\* Mann-Whitney U*

*HHR- Horizontal healing rate*

*VHR- Vertical healing rate*

**¶** Co-morbidities identified included diabetes, gestational diabetes, hypothyroidism and rheumatoid arthritis (unmedicated)

**Table 4: Multivariate analysis: Logistic regression models**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **OR (95%CI)** | **p-value** | **adjOR(95%CI)** | **p-value** | **adjOR(95%CI)** | **p-value** |
| **Initial wound area (cm2)\*** | 0.49 (0.28-0.84) | ***0.01*** | 0.56 (0.31-1.04) | 0.07 | - |  |
| **Initial wound perimeter (cm)\*** | 0.77 (0.61-0.98) | ***0.03*** | - |  | 0.82 (0-.63-1.06) | 0.13 |
| **Bacterial fluorescence** | 0.24 (0.07-0.81) | ***0.02*** | 0.24 (0.06-1.00) | 0.05 | 0.21 (0.05-0.87) | ***0.03*** |
| **OASI**  | 0.10 (0.02-0.58) | ***0.01*** | 0.11 (0.02-0.77) | ***0.03*** | 0.09 (0.01-0.66) | ***0.01*** |

*OR- Odds ratio*

*adjOR- Adjusted OR*

*\** *Wound area and perimeter were analysed separately as they are dependent on each other.*

**Table 5. Comparison of the logistic regression models performance:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **AUC** | **95% CI** | **p-value** |
| **Model 1: Wound Area** | 0.76 | 0.62-0.89 | <0.001 |
| **Model 2: Wound perimeter** | 0.71 | 0.58-0.85 | 0.002 |
| **Model 3: Wound area + fluorescence** | 0.77 | 0.63-0.91 | <0.001 |
| **Model 4: Wound perimeter + fluorescence** | 0.74 | 0.60-0.89 | 0.001 |
| **Model 5: Wound area + fluorescence +OASI** | 0.81 | 0.67-0.94 | <0.001 |
| **Model 6: Wound perimeter + fluorescence + OASI** | 0.80 | 0.66-0.93 | <0.001 |

*AUC-Area under the curve*

**Table 6: Inter-rater reliability and standard error of measurement between naked eye approximation and two-dimensional measurements/three-dimensional measurements**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Device****(vs naked eye approximation)** | **Measurement** | **Mean** | **SD** | **SEM** | **ICC** | **95%CI** |
| **Silhouette** | **Length** | 2.09 | 1.00 | 0.41 | 0.82 | 0.69-0.90 |
| **Width** | 1.00 | 0.52 | 0.27 | 0.75 | 0.56-0.85 |
| **Depth** | 0.40 | 2.78 | 0.17 | 0.62 | 0.32-0.78 |

*SD- Standard deviation*

*SEM- Standard Error of Measurement*

*ICC-Intraclass Correlation*