OSTEOMYELITIS IN TRAUMATIC EXPOSED BONE FOLLOWING FLAP COVERAGE

by

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Author

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ABSTRAK

Pengenalan: Penutupan tulang terdedah berikutan trauma dengan flap tisu adalah penting untuk mencegah osteomielitis dan membantu penyembuhan tulang. Kaedah pembedahan ini sudah dikaji sebelum ini, dengan memperbandingkan masa penutupan tulang dari trauma, dan perbezaan pelbagai komponen flap yang digunakan; faktor yang dikaji adalah keberjayaan hidup flap, jangkitan, osteomielitis dan tempoh penyembuhan tulang, walau bagaimanapun, kajian sebelum ini tidak difokuskan kepada osteomielitis selepas penutupan tulang sahaja.

Objektif: Kajian kami dijalankan untuk mengkaji faktor-faktor yang mempunyai kaitan dengan osteomielitis selepas penutupan tulang dengan flap.

Kaedah: Ini adalah kajian observasi retrospektif yang dijalankan di Hospital Universiti Sains Malaysia. Rekod kes 88 pesakit yang menjalani pembedahan penutupan tulang selepas trauma dengan flap antara tahun 1998 hingga 2006 dikaji. Komplikasi osteomielitis, ukuran panjang tulang terdedah, rekahan tulang patah yang terdedah, masa dari trauma hingga penutupan tulang, dan jangkitan di kawasan flap selepas penutupan tulang dikaji.

Keputusan: Kami melakukan pembedahan 56 flap bebas dan 32 flap tempatan untuk menutup tulang yang terdedah selepas trauma; 46 adalah flap otot, 31 adalah flap fascia dan 11 adalah flap tulang bersama fascia. Kebanyakan pembedahan dijalankan di antara 72 jam dan 90 hari. Purata panjang tulang yang terdedah dalam kumpulan osteomyelitis adalah 4.5 sentimeter (julat=1-32sentimeter), dan kumpulan tiada osteomyelitis adalah 6.86sentimeter (julat=1-15sentimeter).

Kadar kejadian osteomielitis selepas penutupan tulang dengan flap adalah 39.8%. Terdapat korelasi signifikan statistik antara masa dari trauma hingga penutupan tulang (OR=1.027, 95%CI=1.005-1.051, p=0.017), dan jangkitan di kawasan flap selepas penutupan tulang (OR=0.023, 95% CI=0.005-0.102, p=<0.001) dengan osteomielitis. Penutupan tulang yang dilakukan selepas 28.5 hari dikaitkan dengan kadar kejadian osteomielitis yang lebih tinggi. Penyakit diabetes mellitus (OR=2.321, 95%CI=0.728-7.400, p=0.155) mempunyai korelasi dengan osteomyelitis selepas penutupan tulang. Tiada korelasi signifikan statistik antara ukuran panjang tulang terdedah dan rekahan tulang patah yang terdedah dengan osteomyelitis selepas penutupan.

Kesimpulan: Osteomielitis selepas penutupan tulang terdedah biasa berlaku. Faktor risiko termasuk kelewatan dalam melaksanakan pembedahan penutupan, jangkitan pada tapak flap dan penyakit diabetes mellitus. Penutupan tulang terdedah dengan flap perlu dilakukan sebaik sahaja pesakit stabil dan keadaan luka optimum.

ABSTRACT

Introduction: Flap coverage of traumatic exposed bone is important to prevent osteomyelitis and promote bone healing. These surgeries were previously studied, comparing time of bone coverage from trauma, and different components of flaps used; outcomes studied were flap survival, infection, osteomyelitis and duration of bone healing. Previous studies did not focus on osteomyelitis alone after bone coverage.

Objectives: Our study was designed to review the factors associated with osteomyelitis after bone coverage

Methods: This was a single-centre retrospective observational study conducted in Hospital Universiti Sains Malaysia. Case records of 88 patients who underwent traumatic bone coverage with flaps between 1998 till 2006 were reviewed. Osteomyelitis as a complication, length of exposed bone, exposed fracture site, time from trauma to bone coverage, and infection at flap site post coverage were studied.

Results: We performed 56 free flaps and 32 local flaps to cover the traumatic exposed bones; 46 were muscle flaps, 31 were fascia flaps and 11 were osseofasciocutaneous flaps. Most flap coverages were done in between 72 hours and 90 days. Mean of exposed bone length in osteomyelitis group was 4.5cm (range=1-32cm), and non-osteomyelitis group was 6.86cm (range=1-15cm).

Incidence of osteomyelitis after bone coverage with flaps was 39.8%. There were significant statistical correlations between time from trauma to bone coverage (OR=1.027, 95%CI=1.005-1.051, p=0.017), and infection at flap site post coverage (OR=0.023, 95%CI=0.005-0.102, p=<0.001) with osteomyelitis after coverage. Flap coverages done after 28.5 days were associated with higher incidences of osteomyelitis. Incidentally, diabetes mellitus (OR=2.321, 95%CI=0.728-7.400, p=0.155) was found to be associated with osteomyelitis after flap coverage. There were no statistically significant correlations between length of exposed bone and exposed fracture site with osteomyelitis after coverage.

Conclusions: Osteomyelitis after flap coverage of exposed bone is not an uncommon problem. Risk factors include delay in performing flap coverage, infection at flap site after coverage and diabetes mellitus. Bone coverage with flap need to be performed as soon as patients' general and local wound conditions permits, to prevent infections and osteomyelitis.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Trauma is an ever increasing problem, and it is undoubtedly, one of the main causes of morbidity and mortality in our community. Physical trauma is defined as injury to a person's body. It is most commonly caused by road traffic accident (76.76%), fall from height (11.79%), industrial injuries (1.26%) and other injuries including sports, domestic, assault injuries (10.19%) according to Malaysian Trauma Database [1]. In Malaysia, physical trauma is the main contributor of morbidity and mortality of the under 40 age group, third most common cause of hospital admissions, following normal delivery, complications of pregnancy and child birth [2].

One of the major consequences of physical trauma is exposed bone, caused by open fractures, soft tissue loss due to crush or degloving injury, infection, and post-surgical debridement. Osteomyelitis – defined as inflammation of bone caused by infecting organism, is a major complication of exposed bone. Although bone is normally resistant to bacterial colonization, events such as trauma, surgery, presence of foreign bodies or placement of prosthesis may disrupt bony integrity and lead to onset of bone infection. It can also originate from haematogenous spread after bacteraemia [3-8]. Four major factors have been found to predispose to complications after trauma in type III open fracture: massive soft-tissue damage with resultant problems in bony coverage, severe wound contamination, compromised vascularity, and fracture instability [9,10].

With the discovery of pedicled and microvascular free flaps, surgeons have nearly limitless choices to perform coverage for traumatic exposed bone, aiming to prevent osteomyelitis and promote bone healing. Components of the flaps consist of skin, fascia, muscle and bone.

Outcomes after flap coverage surgeries were compared. Factors widely studied were timing of flap coverage and different components of flaps. In these studies, outcomes and complications compared were flap survival, infection, osteomyelitis, and duration of bone healing.

In a series of 532 patients who underwent microsurgical reconstruction following trauma to their extremities, infection rate (1%) was found to be lowest, in the group where flap surgeries were performed within 72 hours, and highest infection rate (17.5%) was found in the group where flap surgeries were performed after 72 hours to 3 months [11,12]. Lower infection rate was found to be associated with shorter hospitalization duration.

Muscle flaps, as compared to fasciocutaneous flaps were found to be superior for coverage of open tibial fractures, for both the rate and quality of fracture healing in murine models [13]. Fasciocutaneous flaps may be superior to muscle flaps for coverage of rapidly uniting metaphysial fractures, while muscle flaps aid in healing and their plasticity aids to obliterate dead space [14].

Choices of local, regional or free flaps have also been compared, with studies suggested that they provided equal benefits for bone coverage [15]. Choices of flaps depend strongly upon availability of soft tissue from local or distant donor locations, surgeons, skills, and microsurgical support team to be performed successfully.

Studies done on coverage of exposed bone almost never failed to mention osteomyelitis as one of the stubborn complication, no matter the types of closure prescribed. Its incidence ranged from 40-60% [9,10,16-19].

Osteomyelitis after flap coverage of exposed bone is an important complication to note, however, knowledge on contributing factors and their association with osteomyelitis after bone coverage with flaps were limited. Previous studies were not focused on exploring osteomyelitis after flap coverage, rather, described outcomes of bone coverages in a collective manner. This study is conducted to narrow this gap of knowledge, by investigating the contributing factors towards osteomyelitis after flap coverage of traumatic exposed bone, with the aim of developing a prognostication and preventive strategies for osteomyelitis after bone coverage with flap, in addition to the current understanding and treatment protocols available.

CHAPTER 2

OBJECTIVES OF THE STUDY

2.1 GENERAL OBJECTIVE

Our general objective is to study the factors predisposing to osteomyelitis in traumatic exposed bone following flap coverage.

2.2 SPECIFIC OBJECTIVES

1. To determine the association between length of exposed bone with osteomyelitis after flap coverage.
2. To determine the association between exposed fracture site with osteomyelitis after flap coverage.
3. To determine the association between infection at flap coverage site with osteomyelitis after flap coverage.
4. To determine the association between time taken to cover exposed bone with flap, with osteomyelitis after flap coverage.

2.3 HYPOTHESES

1. There is significant association between length of exposed bone with osteomyelitis after flap coverage
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3. There is significant association between infection at flap coverage site with osteomyelitis after flap coverage
4. There is significant association between time taken to cover exposed bone with flap, with osteomyelitis after flap coverage.

NULL HYPOTHESES

1. There is no significant association between length of exposed bone with osteomyelitis after flap coverage
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CHAPTER 3

MANUSCRIPT

3.1 TITLE PAGE

"OSTEOMYELITIS IN TRAUMATIC EXPOSED BONE FOLLOWING FLAP COVERAGE"

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Osteomyelitis Following Bone Coverage

3.2 ABSTRACT

Introduction: Flap coverage of traumatic exposed bone is important to prevent osteomyelitis and promote bone healing. These surgeries were previously studied, comparing time of bone coverage from trauma, and different components of flaps used; outcomes studied were flap survival, infection, osteomyelitis and duration of bone healing. Previous studies did not focus on osteomyelitis alone after bone coverage.

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Incidence of osteomyelitis after bone coverage with flaps was 39.8%. There were significant statistical correlations between time from trauma to bone coverage (OR=1.027, 95%CI=1.005-1.051, p=0.017), and infection at flap site post coverage (OR=0.023, 95%CI=0.005-0.102, p=<0.001) with osteomyelitis after coverage. Flap coverages done after 28.5 days were associated with higher incidences of osteomyelitis. Incidentally, diabetes mellitus (OR=2.321, 95%CI=0.728-7.400, p=0.155) was found to be associated with osteomyelitis after flap coverage. There were no statistically significant correlations between length of exposed bone and exposed fracture site with osteomyelitis after coverage.

Conclusions: Osteomyelitis after flap coverage of exposed bone is not an uncommon problem. Risk factors include delay in performing flap coverage, infection at flap site after coverage and diabetes mellitus. Bone coverage with flap need to be performed as soon as patients' general and local wound conditions permits to prevent infections and osteomyelitis.

3.3 INTRODUCTION

Trauma is an ever increasing problem, and is undoubtedly, one of the main causes of morbidity and mortality in our community. According to Malaysia Trauma Database, physical trauma is most often caused by road traffic accident (76.76%), fall from height (11.79%), industrial injuries (1.26%) and other injuries including sports, domestic, assaults (10.19%) [1], and is the main contributor of morbidity and mortality of the under 40 age group, third most common cause of hospital admissions[2].

Exposed bone, is a major complication of physical trauma. It is caused by open fractures, degloving injuries, soft tissue loss after infections or surgical debridements[20,21]. Exposed bone predispose to osteomyelitis. Although bone is normally resistant to bacterial colonization, events such as trauma, surgery, presence of foreign bodies or placement of prosthesis may disrupt bony integrity and lead to onset of bone infection[4,6,22]. It is well understood that bone coverage with flap is important to prevent osteomyelitis and promote further bone healing[9-12].

With the discovery of pedicled and microvascular free flaps, surgeons have nearly limitless choices to perform coverage for traumatic exposed bone. Components of the flaps consist of skin, fascia, muscle and bone[14,16,20,23,24].

Outcomes after flap coverage surgeries were compared. Factors widely studied were timing of flap coverage and different components of flaps. In these studies, outcomes and complications compared were flap survival, infection, osteomyelitis, and duration of bone healing.

In a series of 532 patients who underwent microsurgical reconstruction following trauma to their extremities, infection rate (1%) was found to be lowest, in the group where flap surgeries were performed within 72 hours, and highest infection rate (17.5%) was found in the group where flap surgeries were performed after 72 hours to 3 months[11,12]. Lower infection rate was found to be associated with shorter hospitalization duration.

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Osteomyelitis after flap coverage of exposed bone is an important complication to note, however, knowledge on contributing factors and their association with osteomyelitis after bone coverage with flaps were limited. Previous studies were not focused on exploring osteomyelitis after flap coverage, rather, described outcomes of bone coverages in a collective manner. This study is conducted to narrow this gap of knowledge, by investigating the contributing factors towards osteomyelitis after flap coverage of traumatic exposed bone, with the aim of developing a prognostication and preventive strategies for osteomyelitis after bone coverage with flap, in addition to the current understanding and treatment protocols available.

3.4 MATERIALS AND METHODS

Cohort

88 consecutive patients who underwent flap coverage of traumatic exposed bone at our institution (Hospital Universiti Sains Malaysia) between 1998 till 2006 were retrospectively reviewed. All flap operations were conducted by Plastic and Reconstructive Sciences Unit.

Data Collection

Data were retrieved by reviewing each patient's individual case records. All patients with traumatic exposed bone covered with flap, and complete documentation of factors contributing to the complication of osteomyelitis were included. Diagnosis of osteomyelitis was done based on clinical features of osteomyelitis; fever, chills, pain, local signs of infeections, purulent drainage from wound sinuses, and intraoperative findings of pus and sequester[4,6], raise in Erythrocyte Sedimentation Rate (ESR) ≥20ml/hr (sensitivity=85%, specificity=52.96%)[25], confirmed with plain radiographic changes of periosteal thickening, lytic lesions, endosteal scalloping, osteopenia[26], and the evidence that plain radiography taken after 14 days has the sensitivity of 82%, specificity of 92% and overall accuracy of 83% in diagnosing osteomyelitis[26,27].

The factors of interest in our study were length of exposed bone, exposed fracture site, timing till bone coverage from time of trauma, and infection at flap site post coverage.

Length of exposed bone were recorded as continuous data, in centimeters. Exposed fracture site were recorded in binary data of presence or absence. Timing till bone coverage were recorded as continuous data, in days. Infection at flap site post coverage were recorded as binary data of presence or absence. Diagnosis of infection at flap site was done based on evidence of cellulitis, pus discharge, clinical signs of inflammations, wound breakwown, delayed healing with supportive evidence of positive microorganism culture from tissue.(identifying criteria for wound infection, factors influencing development of wound infection following free flap reconstruction for intraoral cancer)

All data were collected in a customised proforma.

Inclusion and Exclusion Criteria

All patients with traumatic exposed bone, covered with flaps, and has complete documentations of the studied factors and the complication of osteomyelitis were included, whereas those with incomplete documentations were excluded.

Statistical Analysis

Descriptive analyses were performed, the mean for continuous variables, and frequency with percentage for categorical variables were reported.

The variables analysed in this study were length of exposed bone (centimetres), fracture segment (exposed or not exposed), timing till bone coverage from time of trauma (days), infection at flap site after coverage (present or absent), and outcome of osteomyelitis (present or absent).

All the variables were analysed at univariate level with simple binary logistic regression and at multivariate level with multiple logistic regression. The crude (OR) with 95% confidence interval (CI) and p-value were reported.

Statistical analyses were done using SPSS (IBM SPSS version 22.0, IBM. Corp., Armonk, NY, USA).

3.5 RESULTS

Data from 108 patients were collected. 88 patients were evaluated for the outcome of osteomyelitis after flap coverage. 20 patients were excluded from this study for incomplete documentations. In all the 20 excluded patients, exposed bone lengths were not documented.

The demographic and clinical characteristics of the patients were summarised in tables I to VI.

In our series, most of our flap coverages were done between 72 hours and 90 days. Free flaps (n=56) were predominant in numbers as compared to local flaps (n=32). Types of flaps performed were muscle (n=46), fascia (n=31) and bone (n=11). 7 cases underwent exploration after flap procedure; reasons for exploration were anastomosis thrombosis (n=3), pedicle kinking (n=2), venous congestion due to tight positioning (n=1) and skin paddle necrosis (n=1). 5 cases were reported to be complete flap failure; reason being flap necrosis (n=3), arterial thrombosis (n=1), and edge necrosis with exposed and injured pedicle (n=1).

Incidence of osteomyelitis after flap coverage was 39.8% (n=35). Mean age was higher in the osteomyelitis group (mean=30.8, range=6-84) compared to non-osteomyelitis group (mean=25.42, range=1-72), however the difference was not statistically significant.

Percentage of patients with diabetes mellitus (57.14%, n=8) in the osteomyelitis group was higher than the non-osteomyelitis group (42.86%, n=6). The distribution of other medical illnesses: hypertension, chronic kidney disease, peripheral vascular disease, were only present in the non-osteomyelitis group, and were not analysed statistically.

In both groups, most of the cases were caused by motor vehicle accidents, followed by industrial and domestic injuries. Most of the tissue losses were caused by open fractures, and highest number of exposed bone were tibia.

In the group of osteomyelitis, the percentage of patients with exposed fracture site was 42.25% (n=30), whereas in the non-osteomyelitis group, the percentage was 41% (n=57.75). There was no statistically significant difference between the 2 groups.

Mean of exposed bone length in osteomyelitis group was 4.5cm (range=1-32cm), and non-osteomyelitis group was 6.86cm (range=1-15cm). In the osteomyelitis group, most number of patients had exposed bone length between 4 to 6cm, whereas in the non-osteomyelitis group, most number of patients had exposed bone length between 2 to 5cm. The difference between these 2 groups was not statistically significant.

The result of independent T-test was significant for infection at flap coverage site, ($t(86)=7.737$, $p=<0.001$) indicating there was significant difference between osteomyelitis (mean=0.74, SD=-0.443, n=35) and non-osteomyelitis (mean=0.11, SD=0.320, n=53) group in term of infection at flap site after reconstruction (95%CI = -0.804 - -0.456, mean difference -0.630).

Mean hospital stay duration for patients with osteomyelitis was 74.8 days (range=6-142 days), whereas mean hospital stay duration for patients without osteomyelitis was 60.75 days (range=4-154 days). The result of independent T-test for total hospital stay duration compared between the 2 groups (t(86)=-2.084, p=0.040, 95%CI -14.045 – 6.741, mean difference -14.045) indicated there was significant difference between the duration of hospital stay of osteomyelitis (mean=74.80, SD=32.904, n=35) and non-osteomyelitis (mean=60.75, SD=29.608, n=53) group. Those with osteomyelitis had mean 14 days longer duration of hospital stay compared to those with no osteomyelitis.

At univariate level of analysis, there was significant correlation between infection at flap coverage site with osteomyelitis development (Crude OR=0.044, 95%CI=0.014-0.138, p=<0.001), whereas exposed bone length, exposed fracture site, and time from trauma to coverage showed no significant correlation.

At multivariate level of analysis, the presence of diabetes mellitus (OR=0.170, 95%CI= 0.030-1.025, p=0.046), time from trauma to coverage (OR=1.027, 95%CI=1.005-1.051, p=0.017) and infection at flap coverage site (OR=0.023, 95%CI=0.005-0.102, p=<0.001) were found to have significant correlation with the outcome of osteomyelitis. In patients with diabetes mellitus, there was 0.170 times the odd of developing osteomyelitis after coverage of exposed bone. Delay of 1 day in closure of exposed bone, multiples the odds of getting osteomyelitis by 1.027, increases the odds of getting osteomyelitis by 2.7%.

A person who suffered from infection at flap site after coverage had 0.032 times the odds of developing osteomyelitis afterwards.

Cut off point analysis with the Receiver Operating Curve (ROC) showed coverages performed after 28.5 days demonstrated higher possibilities of developing osteomyelitis afterwards (sensitivity=0.714, specificity=0.472).

3.6 DISCUSSION

The incidence of osteomyelitis after bone coverage with flap in our study (39.8%) is fairly consistent with published data worldwide. In a retrospective study by Georgiadis et.al., in 55 patients with Gustillo IIIB and IIIC fractures, who underwent free tissue transfer, 56% of cases had osteomyelitis as a complication[18]. In a study by Fischer et.al., in 43 patients with Gustillo IIIB fractures, 18.2% of the patients had osteomyelitis after early flap coverage, whereas 69.2% of the patients had osteomyelitis after delayed flap coverage[17]. Although previous studies were able to demonstrate the incidence of osteomyelitis after bone coverage, they were not specifically designed to focus only on osteomyelitis itself. These studies reviewed the outcomes of bone coverage by collectively comparing flap survival, infection, osteomyelitis, and duration of bone healing. We focussed on osteomyelitis, and its associated factors.

Three factors identified to be significantly associated with osteomyelitis after bone coverage with flaps were: time (days) from trauma to flap coverage, presence of infection at flap site post coverage, presence of diabetes mellitus. Former two factors were hypothesized in our specific objectives, while the latter was an incidental finding in statistical analysis. The other two studied factors: exposed bone length and exposed fracture site, were found to have no significant association with osteomyelitis after bone coverage with flap.

Time (days) from trauma to flap coverage

Earlier flap coverage was found to be beneficial in terms of decreasing the rate of osteomyelitis. Previous study demonstrated that flap coverage performed within 72 hours, was associated with lesser infection rate and shorter hospital stay, flap coverage performed between 72 hours and 3 months showed highest infection rate[12,28]. While our study showed earlier coverage was beneficial, we were not able to demonstrate the same classification system of time period as this previous study. We operated at a tertiary referral hospital, accepting patients that were previously managed in other hospitals. The flap coverages in our series were mostly performed within 72 houts to 90 days period. Reasons behind delayer flap coverages were delayed referral, poly trauma needing prior stabilizations, uncertainty due to vascular injuries, nonviable tissues and infections. Nevertheless, a cut off time of 28.5 days were demonstrated in our study to be associated with osteomyelitis. The TIME principle was used for wound bed preparation[29-31]. After adequate debridement of necrotic tissues and resolved infections, continuous reassessment and intervention is necessary to ensure that once the local environment and systemic condition of patient is favourable, flap coverage of exposed bone should be performed without delay.

Presence of infection at flap site post coverage

Our study demonstrated there was significant association between infection at flap site post coverage and osteomyelitis. In our series, wounds were prepared, adequate debridement and removal of doubtful necrotic bone segments done intraoperatively to ensure eradication of ongoing infections and removal of infective nidus before coverage. Reasons of post-operative infections may be superficial infections , residual necrotic tissue hidden in wound pockets, and the immature, poorly perfused scars in the wounds[12]. Controlled aseptic environment in operation theatres, prophylaxis antibiotics, control of postoperative septicaemia and adherence to strict aseptic practices during subsequent dressings needed to be ensured, to prevent infections post flap coverages.

Presence of diabetes mellitus

Diabetes mellitus is a well-recognised risk factor of osteomyelitis in diabetic foot ulcer[32], however, its contribution towards osteomyelitis after bone coverage with flap was not extensively studied. Our study demonstrated its significant association with osteomyelitis after traumatic bone coverage. This may be attributed to its inherited problems in wound healing due to macrophages and growth factor defect[33], causing delay in clearing of infective agents from wound environment, and inadequate growth factor release to promote healing. Although no specific glycaemic targets are set for wound healing, the importance of sustained blood-sugar control should not be underestimated. Besides, meticulous inspection, proper dressings and prophylaxis antibiotics should be prescribed post-operatively, to prevent the complications of diabetes pertaining to wound healings.