

## Surgery

## KEYWORDS:

## TRADITIONAL BONE DRILLING TECHNIQUE FOR LIMB SALVAGE.



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## ABSTRACT

Several conditions like trauma/injury, diabetes, severe infections, ablation associated with malignancies, neuropathy and peripheral vascular diseases are known to threaten functions of limb. Limb salvage/sparing procedures are surgical intervention aimed for salvaging the structure and function of bone by avoiding amputation. Traditional bone drilling is universal surgical intervention utilized for fixation of internal fracture, installation of implants and for conduction of reconstructive surgery. In this review the overview of application of traditional bone drilling technique for limb salvage.

## INTRODUCTION.

In human beings, lower extremities are both exceptionally longer and robust specially adapted for bearing the entire weight of the body and the locomotion. Various factors are known to threaten overall anatomical structure and physiology of the limb. These include trauma/injury, diabetes, severe infections, ablation associated with malignancies, neuropathy and peripheral vascular diseases (PVDs).<sup>1</sup> Structural and functional loss of limb severely afflicts well-being of an individual.

Limb salvage also known as limb sparing procedures/techniques are surgical intervention aimed for salvaging the structure and function of bone by avoiding amputation. Historically, the beginning of limb salvage techniques dates back to the era after the World War I, when Winnett Orr introduced and later Trueta, developed the technique of 'closed plaster treatment'. Before introduction of limb salvage technique, amputation was the only surgical procedure done for severely damaged limbs.<sup>2</sup> Introduction of microsurgery in 1960 revolutionized the process of limb salvage.<sup>1</sup> Till recent date, the process of limb salvage is based on the concept involving debridement of damaged tissue followed by stabilization. The decision of salvage of limb is dependent on status and factors of an injury. The factors include type of tissue injury, location of injury, contamination and multitude of physiological status. Limb salvage decision is also dependent on the wish of the patient and available resources.<sup>3,5</sup>

Limb salvage/sparing can be performed using various techniques including arthrodesis, arthroplasty, endoprosthetic reconstruction, various types of implants, rotationplasty, osseointegration limb replacement, fasciotomy, and revascularization.<sup>6,9</sup> Traditional bone drilling is universal surgical intervention utilized for fixation of

internal fracture, installation of implants and for conduction of reconstructive surgery.<sup>10</sup> The aim of this review article is to provide the overview of application of traditional bone drilling technique for limb salvage.

## Methodology.

For preparation of this review article, a search was made on 'Search Engines' like 'PubMed' and 'Google Scholar' by using MeSH like 'limb salvage', 'limb sparing' and 'bone drilling'. Relevant review articles, original articles, case studies and case series were retrieved. These articles were used for preparation of review article.

## Limb salvage/sparing.

Limb salvage/sparing the surgical process aimed to preserve normal functioning of limb without the need for a prosthesis.<sup>11</sup> It is process of saving the limb from getting otherwise amputated. In addition to this, the aim of limb salvage is to achieve a plantigrade foot that provides the most appreciable level of function and the shortest period of recovery.<sup>1</sup>

Various conditions are known to necessitate limb salvage are as follows:

1. Trauma/injury: It is the commonest cause of salvage surgery of lower extremity. As high velocity trauma is often associated with the risk of fatal injuries, it requires a quick action. Various factors including the vascularity, sensibility, level of severity of soft-tissue and skeletal loss should be assessed on emergency basis with routine X-rays.<sup>12</sup> Computed tomography (CT) angiogram or Doppler examination aid to rule out suspicion of vascular occlusion especially in multilevel traumas/injuries. Despite of availability of various scoring systems are available to assist surgeon in decision making (the mangled extremity severity score, the Limb Salvage Index, the Predictive Salvage Index, the nerve injury, the Hannover Fracture Scale-98), the decision is individualised as per the patient.<sup>1</sup>

Recently Teso *et al* (2021) suggested pedal acceleration time as an important and novel marker for prediction of limb salvage and also proposed to include PAT in the WIFI classification. In the study of these authors, patients with PAT class 1 and 2 were associated with limb salvage.<sup>12</sup>

2. Stump sparing/salvage: When there are extensive defects in bone and soft tissues as a result of trauma of lower extremities, the surgical management may involve inevitable amputation in some cases. However while performing amputation of lower extremities; the primary aim is to preserve/save the knee joint. Preservation of knee joint aid to reduce energy expenditure during movement in addition to maintaining of normal gait in cases where knee joint is functioning. Free fillet foot flap, sandwich flaps and micro-vascular

free flaps are utilized for salvage of limb of below knee amputation stump.<sup>1,13</sup> Qian *et al* (2023) highlighted the importance of free flap transplantation as both important and advanced technique for emergency treatment of mangled limbs.<sup>14</sup>

3. Cancer ablation: In malignancies, like soft-tissue sarcoma, the lower limbs are frequently involved as compared to upper limb. Surgical excision along with adjuvant radio and chemotherapy is mainstay of treatment. Limb salvage in cancer patients is multidisciplinary approach and requires a team work involving physicians and surgeons from various specialties and super specialties like oncology, pathology, resective and reconstructive surgery and orthopaedics. Expandable and non-expandable tumour prostheses, resection arthroplasties, distraction osteogenesis, segment transport or total joint replacements are some of recent techniques employed for limb salvage.<sup>1</sup> Barner-Rasmussen *et al* and Topham *et al* suggested microvascular reconstructive as a safe and reliable surgical intervention for limb salvage in soft tissue sarcomas.<sup>15,16</sup>

4. Chronic/severe infections: Infections like chronic osteomyelitis are often associated with conditions like fracture non-union, limb length discrepancy and deformity that necessitates surgical interventions. Limb salvage is important alternative to amputation in fracture related infections. Various techniques like free tissue transfer, ascularized osteocutaneous fibular graft, vascularized osteocutaneous fibular graft and bone transplant have been used for limb salvage in chronic/severe infections.<sup>17</sup>

5. Peripheral vascular disease (PVD): In addition to adverse cardiac outcomes, PVD often leads to disability or crippling. In USA PVD of lower extremity affects approximately 8.5 million. Globally lower extremity PVD affects nearly 202 million peoples.<sup>18</sup> In PVD patients antithrombotic therapy is known to improve limb salvage.<sup>19</sup> Masaki *et al* (2013), reported endovascular procedures in combination with surgical bypass to reduce the extent of surgery and the graft length. These authors also highlighted the fact that these surgical procedures are associated with limb salvage rate of 87%.<sup>20</sup> Parmar *et al* (2019) reported that, use of statin use in PVD patients with after intervention is associated with improved limb salvage and improved survival.<sup>18</sup> Gabel *et al* (2020) concluded that with multidisciplinary approach in patients with mild to moderate ischemia and tissue loss wound healing and limb salvage can be achieved to an acceptable rates.<sup>21</sup>

6. Diabetic wound/non healing ulcers: As diabetic foot infection is both foot threatening and life threatening, prompt diagnosis and treatment including emergent surgical intervention (if essential) is paramount for tissue preservation and prevention of limb loss.<sup>22</sup> Therapeutic modalities for severe diabetic foot infections includes optimising of patients, vascular insufficiency revision, aggressive debridement and use of well-vascularised tissue cover.<sup>1</sup> Oh *et al* (2013) reported that reconstruction of diabetic by using free flaps is associated with more than 91% success rates and increases the 5 years limb salvage rate by 86%.<sup>22</sup> In recent years, plastic and reconstructive surgeons have adapted endovascular intervention as the initial form of revascularisation for performing free tissue transfer to the native diseased vessels for limb salvage/sparing in patients with severe diabetic foot injuries.<sup>23</sup>

7. Exposed prosthesis: In addition to implant loss, exposed prosthesis poses a potential risk of disability and additional financial burden on patients. The therapeutic regimen for exposed prosthesis includes irrigation, debridement, antimicrobial therapy and removal prosthesis. Several factors should be considered while making a decision to remove prosthetic device. These include location and duration of hardware exposure, type and duration of infection and hardware loosening. Viol *et al.*, (2009) concluded that surgical soft-tissue coverage may increase the chance of hardware salvage conditions where hardware is clinically stable, time of exposure is less than 2 weeks, infection is under control and the

hardware is located for the purpose of bony consolidation.<sup>24</sup> As exposed vascular grafts are usually life- and limb-threatening, there is acute need of emergency intervention including early debridement and muscle flap coverage to salvage the graft.

Traditional Bone drilling technique for limb salvage.

Bone drilling is a routine surgical procedure where hole is produced in a bone for insertion of screw to fix the fractured parts for immobilization.<sup>25</sup> Surgical bone drilling has various applications and is performed for correction of bone fractures, installation of prosthetics and therapy.<sup>26</sup> Since its introduction in modern surgery by Carl Hansmann in 1886, bone drilling technique is applied in various procedures.<sup>26,27</sup> These include:

1. Orthopaedic surgical procedures like total knee arthroplasty for treating osteoarthritis where bone drilling is done for making holes in the intramedullary canal along the anatomical axis of the femur.
2. Neurosurgical procedures like craniotomy where small burr holes are produced to remove a skull section in order to expose the brain for resection of tumor resection and also to relieve pressure on the underlying brain.
3. Otolaryngological surgery like stapedotomy (surgical intervention performed in mid ear to treat hearing loss due to abnormal bone growth i.e. otosclerosis) where bone drilling is performed for excision of abnormal bone to create a small hole in the stapes bone for replacement with a stapes prosthesis.
4. Dental treatment involves drilling for placing dental implants.
5. Therapeutic treatment for osteoarthritis and osteonecrosis.
6. Stimulating a spontaneous repair reaction by drilling (Pride drilling) holes into the sub-chondral bone-marrow spaces underneath regions of damaged articular cartilage.
7. To relieve intra-osseous hypertension and to accelerate infract revascularization and repair.
8. To prevent the collapse of the necrotic femoral head.

There are two major challenges in bone drilling procedure. First, the mechanical force applied during cutting of the bone and second, the thermal damage produced. In bone drilling, principally there two major mechanical forces the thrust force and torque. These forces may lead to drill-bit breakage that occurs during drilling of bone.<sup>25,26</sup> Elevated torque exerts shear stresses that exceed the drill bit strength and results to fracture.<sup>26</sup>

The breakage may interfere with the insertion of other devices or cause corrosive reactions with surrounding tissues. These conditions necessitate the follow-up procedures in order to remove the broken drill bit.<sup>26</sup> Excessive drilling forces may lead to protrusion of drill bit from the bone exit which can damage the bone and its surrounding tissues.<sup>26</sup> Additionally, 'microcracks' may be also produced onto the surface of bone due to excessive drilling force. These 'microcracks' may further propagate to larger cracks, which may cause loosening of the implant and finally to bone fracture due to fatigue failure.<sup>26</sup> The thermal rise generated during the process of bone drilling may result in osteonecrosis. In recent years, many multidisciplinary studies are conducted to address these issues. Therefore traditional bone drilling technique can be looked upon, a reliable method of bone salvage.

## CONCLUSION.

Traditional bone drilling is performed in various surgeries to correct fractures, install implants, treat diseases, or as a precursor to further surgery. However it's application in limb salvage remain largely unutilized. Being easy to perform and cost effective, traditional bone drilling technique appears to have scope in limb salvage.

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