



## Wounds Healing and Limb Saving Surgery

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### Abstract

**Background:** Wounds healing during different ancient times from the history to new century, mostly the last three decades. We evaluate the criteria that dealing with wounds to prevent amputation during these different times from the history, with different methods used for the treatment that were applied for the wound happen at that period.

**Aim of Study:** To evaluate the wound healing from the history (B.C) before century in the previous times, plus after century with the principle criteria in dealing with the wound during that times in the war. Compare to wound care in recent centuries specially the last three decades with advance modern wound care to prevent amputation. Also, visualized patient with wound healing in principle of limb saving procedures.

**Methods:** This retrospective plus prospective studies were varieties of different methods and substances used for wound healing, from the history basis in scientific efficacy for wound healing treatments plus amputations rate happen at that times were used. Compared to recent centuries plan treated of these wounded patients also depend on amputations rate. In comparative study 200 patients, classified into two groups collected randomly specified dealing with the wounds during war, accidents. Group A 100 patients, old centuries were the injuries wounds treated by principles which were used at that times plus the amputation rate, Compared to Group B 100 patients, in Sulaimani Teaching Hospital from June 2006 till July 2015, were modern recent centuries used the principles that dealing with the wounds during the War, also we depend on amputation rate. We evaluate the exact principle criteria that dealing with wound healing from the history to compare to Modern recent centuries wounded care & healing, especially with advanced in technological development to see any difference, with advantages that improve wound care & healing in time factors return the patients early to the job. Also, we presented as example of injured patients to identify the limb saving procedure post wound healing.

**Results:** This is a retrospective plus prospective study to evaluate the outcome measurements. The old history plus post centuries period, versus the modern recent centuries wound healing criteria with advantages of limb saving principles. Both group A & Group B significant reduction in the mean LSI Limb Saving Index, plus time factors for healing improved from baseline were seen at all follow up for precenturies period group A and group B. Also, there were significant statistical differences, functional outcome with clinical improvements, plus decrease rate of amputation, complications plus decrease of morbidity / mortality ratio for groups B, were used the advance technology plus Antiseptics, Antibiotics with new principle in ligation, instrumentation, usage of material with substance were used for complete wound healing as early as possible, compared to group A wound healing principle from history period (p value <0.0001).

**Conclusions:** We concluded that both group A, group B, the principle of wound healing are same. The advantages of recent technology plus usage of the material, substances, instrumentation lead to decrease rate of amputation. Also decrease rate of morbidities & mortalities were observed even with advance technology in the war with different explosive material were used in compare to previous war weapon used.

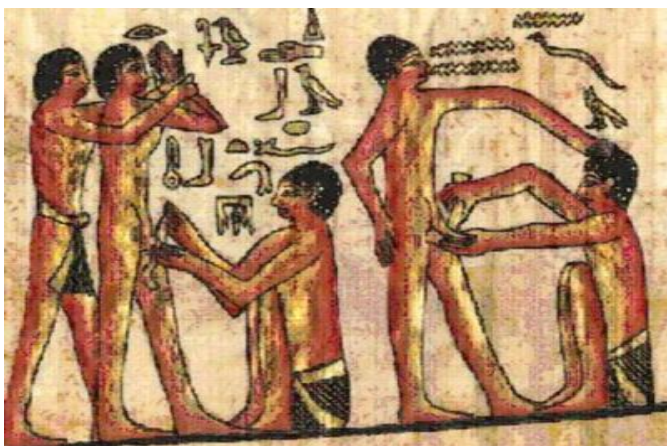
### Introduction

**There are 6 Steps of the Wound Healing**

**Process:** As the body engages in wound healing, a

wonderful process occurs throughout each of the systems that comprise your body. There are six wound healing stages, in order to completely

closure the wound; Rapid hemostasis, Inflammation, Proliferation and migration, Angiogenesis, re epithelialization, Synthesis.<sup>(1,2,3)</sup> Amputation; Limb loss is one of the most physically and psychologically devastating events that can happen to a person. Despite advances in medicine and surgery, amputation continues to be a large problem in the world. It is believed that amputations were performed in the Neolithic times, from evidence of saws of stone and bone and what appears to be amputated bone stumps in skeletons of the period.<sup>(4,5,6)</sup> The first recorded instance of amputations and prosthetic replacement appears in the book of the Vedas, written in Sanskrit in India. The oldest of the Vedas is the Rig-Veda, which is believed to have been compiled between 3,500 and 1,800 BC It records that the leg of Queen Vishpla was amputated in battle. After healing of the repaired wound, an iron leg was fitted to enable Queen Vishpla to walk and to return to the battlefield.<sup>(3,4,7)</sup>



**Fig.1:** Queen Vishpla treatment of wounded leg during the war (The first recorded instance of amputations and prosthetic replacement appears in the book of the Vedas, written in Sanskrit in India. After healing of the repaired wound, an iron leg was fitted to enable Queen Vishpla to walk and to return to the battlefield).<sup>3,4,7</sup>



**Fig.2:** From the ancient pyramids to World War I, different prosthetic types (prosthetic replacement appears in the book of the Vedas, written in Sanskrit in India. <sup>3,4,7</sup>

The history of wound healing is the sense, of the history humankind, one of the oldest medical manuscripts known to man is a clay tablet that dates back to 2200 BC this tablet describes, perhaps for the first time, the “three healing gestures”—washing the wounds, making the plasters, and bandaging the wound.<sup>(10,11,12)</sup>

The Babylonian Talmud Centuries of oral tradition written in the 5<sup>th</sup> Century, “An open wound what is the remedy "For stopping the bleeding, cress with vinegar, scraped root of cynodon and the paring of the bramble, or worms from a dunghill.” wet for dry, dry for wet” “Where the wound was healed, but reopened, healed again but reopened. There are five aspects of the injury; for actual damage, for pain, for healing, for loss of employments, and for humiliation.<sup>(10,11,12)</sup>

Wounded care in ancient Egypt Egyptian God of Medicine, the Egyptians may have been the first people to use adhesive bandages Edwin Smith Papyrus 2600 BC. They used the Cooling agents to draw out inflammation; Drying agents, Raw meat bound to the wound, Linen bandages, Honey. The Egyptians may have been the first people to use adhesive bandages and were most certainly the first people to apply honey to the wounds. Honey, grease, and lint were the main components of the most common plaster used by Egyptians.<sup>(10,13,14)</sup>

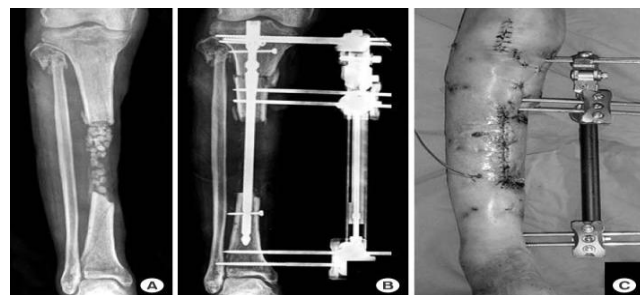
Various types of alcohol were also used in ancient medical practices. One of the first uses was by the Sumerian, who used beer as an antiseptic along

with the dressing of wounds. <sup>(15,16)</sup> Were the Greeks they used wine along with boiled water and vinegar to cleanse wounds. The Greeks, specifically Hippocrates (430-377 BC), were also the first to establish the four cardinal signs of inflammation: redness, swelling, heat and pain. <sup>(15)</sup>

Honey was utilized for its antibacterial properties that helped heal infected wounds. <sup>(17)</sup> Moreover, honey was used as a topical ointment. This technique will support in the reduction of pain, inflammation, swelling, and the antibacterial features. <sup>(19)</sup> Turmeric was used in the ancient times to promote wound healing as an antioxidant. <sup>(18)</sup>

**Modern types of wound dressing include:** dry dressings, wet-to-dry dressings, chemical-impregnated dressings, foam dressings, alginate dressings, hydro-fiber dressings, transparent film dressings, hydrogel dressings, and hydrocolloid dressings. All of the listed dressing types require different materials to complete the dressing. <sup>(19)</sup> Medical leeches were cleared as a medical device in 2004 after being an indispensable tool in the 19th century. Leeches have the ability to assist with compromised tissue with the components of their saliva. Their saliva contains a local anesthetic, thrombin inhibitor, antibiotic properties and a histamine-like vasodilator. These capabilities help in surgeries such as transplants, skin grafts, and even reconstructive surgeries. <sup>(20)</sup> Medical maggots were first utilized by military medical aids during World War 2. They worked as biomedical debriding agents by ingesting bacteria and break them down within their intestines. Maggots give off an enzyme that disinfects wounds and promotes healing and this is why they became the first organism in the United States that were used as a medical device in January 2004. <sup>(21)</sup>

It was not until the 18th century that surgery began to be considered as a distinct and respected branch of medicine. In the 19th century, the antiseptic technique was a major breakthrough. The introduction of antibiotics helped control infections and decrease mortality. <sup>(10,22)</sup>



**Fig.3:** Bone Lengthening (carraging) Procedure



**Fig.4:** Healing time

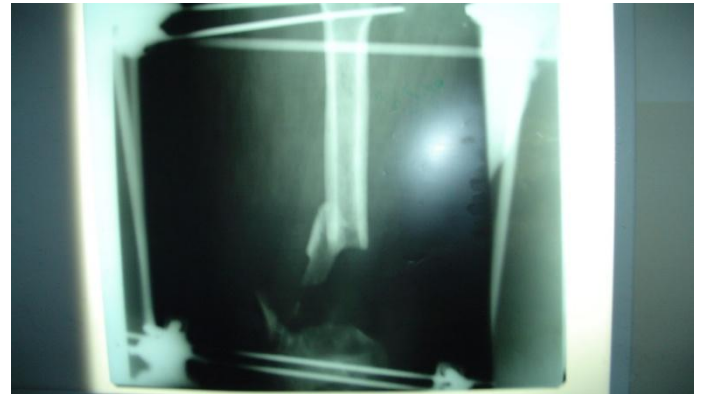
### Methods

This retrospective plus prospective studies were varieties of different methods and substances used for wound healing, from the history basis in scientific efficacy for wound healing treatments plus amputations rate happen at that times were used, in compared to recent centuries, the last three decades. Plan treated of these wounded patients also depend on amputations rate. In comparative study classified into two groups, collected 200 patients randomly specified dealing with the wounds plus amputation rate during war. Group A 100 patients, old centuries also recent centuries were the injured wounds patients treated by principles which were used at that times plus study the amputation rate. Compared to Group B, 100 patients, in Sulaimani Teaching Hospital from June 2006 till July 2015, were modern recent centuries used the principles that dealing with the wounds during the War, plus advance in technology specifically in last 3 decades, also depend on amputation rates. We evaluate the exact principle criteria that dealing with wound healing from the history to compare to Modern recent centuries wounded care & healing, especially with advanced in technological development to see any difference, with advantages that

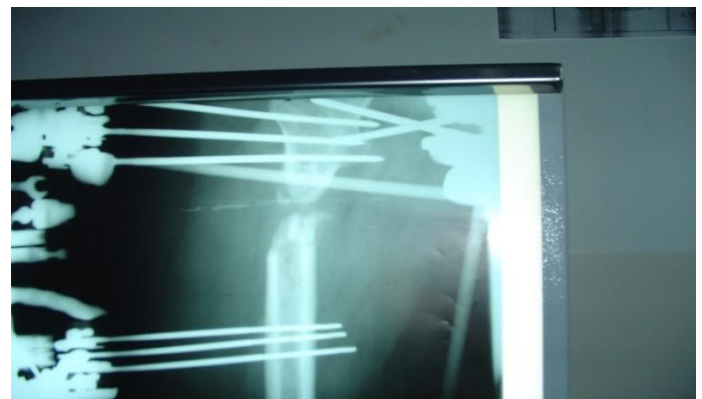
improve wound care with time factors for healing, the return patients early to the job. Also, we study one of my patients as example to identify the limb saving procedure post wound healing. We evaluate the exact principle criteria that dealing with wound healing, plus factors prevent early amputation that depend in modern wounded care & healing. With limb saving procedures to decreases rates of amputations; through skin reconstruction plus decreases the gap of the wound ,eliminates any cavitation by advantages of skin carrying procedures by usage of K wires plus cerclages flexible wires will decrease the gap gradually until complete closure of the skin .bone gap with bone loss were treated by bone carrying procedures especially with advanced in technological development with over design external fixation devices to eliminates any gap in the bone. Later on, the bone graft in some cases to enhance bone healing. Arteries were treated by reconstruction repair for limb saving arterial blood supplies, specially the availability of the vascular reconstruction team with the required instruments nearby field. The Muscles were treated by advancement or transfers, the nerves treated by usage the advantages of magnification power or microscopic techniques. However, it takes times, instrumentations, equipment's, with the facilities, in spite of cost but the limb saving is best choices than amputation as life saving measures for human being are superior to the above requirements. Early Wound Healing Scores with time factors will improved the healing from baseline were seen at all follow up for precenturies period group A and group B. LSI Limb salvage index (Artery, Nerve, Bone, Skin, Musculotendinous unit, Deep Vein, Warm ischemia) were evaluate the rate of amputations in group B, compared to rate happen in group A. Evaluate any difference, with advantages that improve wound care plus healing in time factors with return the patients early to the job. Also, the high outcome to prevent early amputation as example of my patient to identify the limb saving procedure post wound healing.



**Fig.5:** Overdesign External Fixation (daily lengthening simply done by the patient just rotation the device 1 mm)



**Fig.6:** Overdesign External Fixation



**Fig.7:** Osteotomy



**Fig.8:** Process of Bone Lengthening



**Fig.9:** Process of Bone Lengthening complete / prepare for bone graft



**Fig.10:** Leg same length during healing process daily rehabilitation

**Results**

This is a retrospective plus prospective study to evaluate the outcome measurements from the old history times plus before centuries period versus the modern recent centuries wound healing criteria with advantages of limb saving principles. Both group A & Group B significant reduction in the mean LSI Limb Saving Index, plus the time factors for healing improved from baseline were seen at all follow up for precenturies period group A and group B. Also, there were significant statistical differences, functional outcome with clinical improvements, plus decrease rate of amputation, plus decrease of morbidity / mortality ratio for groups B, were used the advance technology plus Antiseptics, Antibiotics with new principle in ligation, instrumentation, usage of material, equipment's, facilities, were used for complete wound healing as early as possible. Compared to group A, that were applied the

wound healing principle from old before centuries historical period to get the results of (p value <0.0001).

There are no major differences in criteria of wound caring principles between group A, before centuries period plus after centuries in treatment of limb injury during the war. Compare to group B, were the advance technology plus modern therapy with all required equipment's, facilities available. During application of LSI Limb Saving Index the main ratio between them mostly depend on amputation rates.

**Table 1.** Limb salvage index  
**Limb salvage index**

<b>Artery</b>	
Contusion, intimal tear, partial laceration	0
Occlusion of two or more shank vessels, no pedal pulses felt	1
Complete occlusion of femoral or three shank vessels	2
<b>Nerve</b>	
Contusions, stretch, minimal laceration	0
Partial transaction or avulsion of sciatic nerve	1
Complete transaction or avulsion of sciatic nerve	2
<b>Bone</b>	
Closed or open fracture with minimum comminution	0
Closed fracture at two or more sites at same limb;	1
Open fracture with comminution or moderate to large displacement with bone loss < 5 cm	2
Bone loss more than 5 cm Grade IIIB or IIIC	3
<b>Skin</b>	
Clean injury, primary repair, first degree burn	0
Delayed closure due to contamination requiring skin graft or flap, second or third degree burn	1
<b>Musculotendinous unit</b>	
Laceration or avulsion involving the single compartment or tendon	0
Complete avulsion injury involving two or more tendon	1
<b>Deep Vein</b>	
Contusion, partial laceration	0
Complete laceration, avulsion or thrombosis	1
<b>Warm ischemia</b>	
Less than six hours	0
6-9 hours	1
9-12 hours	2
12-15 hours	3
More than 15 hours	4

**Table.2** LSI limb saving index score (the main scoring rate for each involved injured part).

Characters of Patients	Group A	Group B
No. of patients	100	100
Mean of age	34 years	31 years
1. Artery	2	2
2. Nerve	2	1
3. Bone	3	3
4. Skin	1	1
5. Musculotendinous unit	1	1
6. Deep vein	1	1
7. Warm ischemia	4	3
Total Score	14	12

**Table.3** With no major differences between group A in compare to group B in LSI Limb Saving Index However, high rate of immediate plus delayed amputation in group B compare to group A.

<i>Characters of patients</i>	<i>Group A</i>	<i>Group B</i>
No. of patients	100	100
Mean of age	34 years	31 years
Immediate Amputation	70 %	20 %
Delayed Amputation post wound caring	15 %	5 %
Total score / Non-Amputation %	15 %	75 %
P VALUE	0.08	<0.0001

### Discussion

Wound healing is same principle in the old centuries with the modern century with advanced technology plus all equipment's with facilities available for complete wound healing. However, the lower rate of limb amputation in last decade compare to old centuries when the usage of new advance technology decreases the rate of amputation.

Regarding time of hospitalization, Georgiadis et al. and Gregory describe that amputation leads to a shorter hospitalization time and a lower number of surgical procedures. We report a large number of

surgeries performed after emergency care. However, high rate of amputation collected the group before century compare to low rate of amputation in recent modern century. Both for reconstructed injuries and amputated ones, mostly need of frequent surgical debridement.<sup>(23,24)</sup>

Our cases amputated at emergency in recent modern time achieved 25 % according to the LSI Limb Saving index, these would not require such resource. However, both presented severely injuries along with smashing, which, according to LSI Limb Saving Index there is no much differences in the score between group A and

group B. however, amputation rates of 85% in group A in compare to group B were 25% amputation rate. <sup>(25,26)</sup>

The absolute indication for lower limbs' primary amputation includes full avulsion of the limb, neurological deficit, hot ischemia higher than six hours, impossibility of reestablishing stream, and gaseous gangrene. Furthermore, the duration of ischemic times exceeding 6 hours are indications for the primary amputation; Peripheral vascular disease (PVD), trauma, tumors, infections, congenital limb deficiency.

Were the advantages of availability of nearby hospitals center in the field with specialized team, will decrease the rate of amputation to that percentage in our LSI Limb Saving Index Scoring System. <sup>(27,28)</sup>

Despite the high costs of advanced wound care therapies, it is possible that they may be cost effective to improve wound healing; reduce morbidity, hospitalizations, medical care compare to amputation rate. However, the costs effectiveness of material, facilities, equipment's were used, the limb saving procedures regards as same as lifesaving principles were used for any patients.

### Conclusions

We concluded that both group A, group B, the principles of wound healing are same. The advantages of recent technology plus usage of the material, instrumentation, equipment's, facilities lead to decrease rate of amputations, plus decrease morbidities & mortalities. limb saving procedures same as lifesaving principles were observed even with advance technology in the war with different explosive material were used in compare to previous war weapon used.

Finally, in the last years, a lot of new techniques try limb salvage were developed. The collaboration between Orthopaedic surgeon, plastic surgeon and vascular surgeon is very important in the field for a good results treatment and prevent the amputations.

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