MICROSURGERY OF WAR

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Dr. Luis Bermudez R., MD.

As Sergeant Surgeon to King Charles II, Richard Wiseman (1622-1676) described the war wounds: “Wounds made by gun-shot are the most complicate sort of wounds that can be inflicted: For they are not only solution of continuity, but have joined with them contusion, attrition and dilacerations, in a high vehement kind. To this we may add all sorts of fractures and accidents, as haemorrhagia, inflammation, erysipelas, gangrene, and sphacelus; besides the extraneous bodies which are violently carried into the wound, and multiply indications….”(1).
Against my initial thoughts, when we compare the water colors of patients from the First World War with the pictures of patients that we currently deal with at the Military Hospital today, the characteristics of the wounds are amazingly similar.

Figure 1.

Figure 2.

Figure 1: *Water Color of patient injured during the First World War (1918).From the Gillies Archives of the Queen Mary’s Hospital, Sidecup, UK.* ***Figure 2:*** *Digital picture of patient of the Military Hospital in Bogotá, Colombia (2002).*

However some of the current war wounds are worst, especially those caused by the non-conventional arms like the antipersonnel mines. Those arms were not used during the First World War and some of them are sadly our own patrimony. The non-conventional arms we are dealing with more extensive injuries and harder to treat, recently I have to see one patient who had lost the legs, the eyes and one hand.

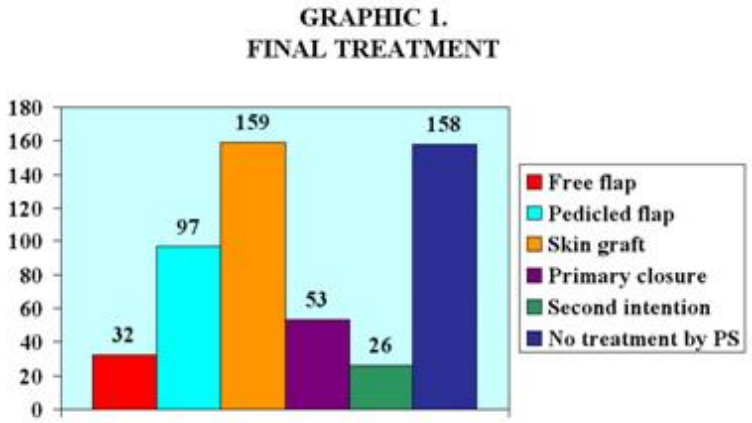
Figure 3.

Figure 4.

Figure 3: *Wounds caused by an explosion of a propane gas recipient, with compromise of the eyes y the complete face.* ***Figure 4:*** *Lesions caused by anti-personnel mine explosion, amputation of right leg at the knee, open fracture of left tibia and fibula, exposure of the knee joint with lost of the patella.*

What is now considered Modern Plastic Surgery was born in the war, it was after the World War I when appear surgeons as Morestin, Lexer, Ganzer, Lindemann, Kilner, Burian, Esser, Kasanjian, Blair and Gillies. Harold Gillies was established at the Queen's Hospital, Sidecup, were developed the most important treatment center for British and allies military casualties. The Queen's Hospital, Sidecup, become the most important center of Plastic and Maxillofacial Surgery in Europe, between 1917 and 1921, 5000 patients with war wounds of the face - mainly gunshot- were admitted. The patients were treated using well known procedures like the frontal flap based in the supratrochear artery described initially in other wars in India, when the antibiotics and the anesthesia were still so far from that we know now. In the **Case 1** we can see the reconstructive process of the nose with a frontal flap based in the superficial temporal artery.
Gillies at the Queen's Hospital, was who developed the concept of tube flaps as the only way to transfer great amounts of tissue to the face reconstructing the severe deformities left by the war in the soldiers. A tube flaps was a piece of skin folded and turned into a tube, creating a pedicle for a random flap; those flaps needed at least 4 surgical procedures with 4 weeks between them, to finally transfer the piece of skin. In the **Case 2** we can see the chronology of transfer of a tube flap from the upper thorax to reconstruct a gunshot wound of the maxilla. When the amounts of tissue were bigger, the surgeons use to take the tube flaps from the abdomen using a extremity as carrier as we can see in the **Case 3**.
The tube flaps were the cornerstone of the plastic Surgery in the treatment of complex injuries during the next 60 years, with impressive results; but with the disadvantage of the need of several surgical procedures and some bizarre uncomfortable positions, I would say they were torturing positions. The evolution of Plastic Surgery has been huge, the craniofacial surgery, microsurgery, the knowledge of the vascular patterns of the flaps, the tissue expanders, the distraction osteogenesis, the osteointegrated implants, etc. were born during peace time. Today is possible to transfer big amounts of tissue in one surgical procedure, because the knowledge of vascular anatomy and a better design of flaps. Flaps like the frontal, described around 800 BC (in India the nose use to be amputated to the conquered after a war or as punishment of infidelity to women) are still the first option in the nose reconstruction, as we can see in **Case 4**. In many of our young patients the forehead is too short, and it is difficult to reconstruct the tip of nose with the frontal flap; in those patients we insert a tissue expander 3 months before the secondary reconstruction of the nose, being able to close primarily the donor site and having more tissue for the reconstruction, as we can see in **Case 5**.
The muscle and muscle-skin flaps, popularized during the 70s, are very useful saving several surgical procedures as the described for the tube flaps. Muscle flaps are important tools in the head and neck reconstruction, however they use most of its length as pedicle and the useful part of flap is small. The exception to the previous statement is the temporal muscle flap because its localization, more of the 50% of the length of this flap is useful, **Case 6.**
Today microsurgery is the ideal method to transfer - in one surgery- great amounts and kind of tissues, providing the necessary elements to reconstruct the complex head and neck lesions left by the war **Cases 7 to 16**.
The evolution of the surgery for reconstruction of extremities mainly the lower limbs, has been extremely different, because the extremities has been easily amputated from long time ago, and during the First World War and Second world war was the surgical option in severe injured limbs. During the Vietnam War with the recently developed vascular surgery was possible to save hundreds of limbs, but the issue of save functional extremities remained.
Always has been easier to amputate than perform complex reconstructive surgery of the lower extremities, but

during the last 20 years because to the coordinated work of orthopedic surgeons (External Bone Fixators, Distraction Osteogenesis, aggressive debridement), Plastic Surgeons (Local Flaps, Free Flaps, Nerve Reconstruction) and Rehabilitation Medicine, is possible to save more functional lower limbs. Microsurgery again is the cornerstone in the reconstruction of those complex injuries, **Cases 12 to 16**.



Taken from: Free Flaps in War Wounds. Plastic Surgical Forum. PSEF 2000 **(3).**

Figure 5. *Graphic showing the reconstructive procedures performed by the Plastic Surgery Division at the Military Hospital, Bogota, Colombia. August 1996 to November 1999.*

In a retrospective review of the 367 patients treated for war wounds, by the Plastic Surgery Division at the Military Hospital in Bogotá between August 1996 and November 1999 (3), we perform 32 free flaps, 97 pedicle flaps, 159 skin grafts, and 53 primary closures. Besides the complexity of the wounds treated, our failure rate in patients with war wounds was to high, 11.4%. We changed our surgical approach in those patients and designed a new review analysis.

OUR OUTCOME

During 6 years I performed 161 free flaps in 158 patients, 61 free flaps were used for war wound reconstruction and the other 100 for pathologies non war wound related (congenital, cancer, facial paralysis other trauma). A war wound was defined as a wound caused by a high velocity gunshot (rifle), antipersonnel or land mines, or any other artifact used for military; low velocity gunshot wounds (pistol) or burns were excluded.

Against Dr. Godina recommendations about timing in the reconstruction of severe wounds, the microsurgical reconstruction of the war wounds was done after 72 hours. In our Hospital the timing of reconstruction of war wounds is almost impossible to modify, because the casualties happen faraway in the countryside, the patient has to be evacuated from the “battlefield”, treated in local hospitals and just the very complex cases are sent to the Military Hospital after some days. Even if the patient arrived to the hospital into the first 3 days of injury (what is really rare) we would not be able to reconstruct this patient into the first 72 hours, due to administrative issues.

For the study **(4)** free flaps were divided in two groups for the purpose of review. Group 1 free flaps performed between August 1996 and July 1999. Group 2 free flaps performed between August 1999 and august 2002. The non war wound free flaps were used as control in both groups.

Group 1 (1996-1999). 35 free flaps for war wound reconstruction. Control group of 51 free flaps for non war wound reconstruction. Average of time elapsed from the injury to the final surgery 15.9 days. Failure rate in

war wound free flaps 11.4%. Failure rate in non war wound control group 0%.
Group 2 (1999-2002). 26 free flaps for war wound reconstruction. Control group of 49 free flaps for no e reconstruction. Average of time elapsed from the injury to the final surgery 23.2 days. Failure rate in war wound free flaps 3.8%. Failure rate in non war wound control group 2%.
The only differences between the two groups were:

1. The experience gained in the microsurgical reconstruction of the war wounds.
2. Choosing of the donor artery in a different muscle compartment of the injury.

In this sample the timing of the micro vascular procedure in relation to the injury was not an important factor in the improvement of the survival rate of the free flaps.
Compartment concept (hypothesis): The extension of the fibrosis occurs along the same compartment of the injury surrounding the vessels, but if we use vessels of different compartment they are free of fibrosis and the risk of failure is lower. For several micro surgeons the posterior tibial artery is safer as recipient than the anterior tibial artery, the physiological explanation is that most of the injuries treated with free flaps in the leg are in the anterior compartment.
When we looked for an explanation of the free flap failure we found:
Group 1(4 failures, all of them in war wounded patients): one was the first free flap performed, and three were free flaps in extremities were the recipient vessel was in the same compartment of the injury.
Group 2 (2 failures, one in a war wounded patient and one in a no war wounded patient): both in head and neck reconstruction, one of them because tension of the pedicle and another because compression of the pedicle by a tracheotomy tie (see **Clinical Case 10**).

TABLE 1.
FREE FLAPS IN WAR WOUNDS

	Success	Failure	Failure rate
Group I (96-99)	31	4	11.4%
Group II (99-02)	25	1	3.8%

Figure 6*. Table # 1: Comparison of failure rate between Group I and Group II. The difference was not significant (p: 0.551), but the relative risk of failure was 2.97 higher for group I, with a confidence rank between 0.352-25.048.*

TABLE 2.
FREE FLAPS IN WAR WOUND AND NON-WAR WOUNDS 1996-2002

	Success	Failure	Rate of failure
WWFF	56	5	8.2%
NWWFF	99	1	1%

Figure 7. *Table # 2: Comparison of failure rate between free flaps used for war-wounds reconstruction (WWFF) and free flaps used for non-war wounds reconstruction (NWWFF). The difference was significant (p: 0.056), and the relative risk of failure was 8.2 higher for the WWFF group, with a confidence rank between 0.98 – 68.51.*

CONCLUSION

In major and severe trauma, as the war wounds, the free flap reconstruction is a powerful tool. There is a tendency to have a higher failure rate in free flaps performed to patients with war wounds than to patients with other pathologies (congenital, cancer, accidents), but it is important to understand that these patients have limited or not other options of treatment, as shown in the clinical cases.
I have an improvement in the success rate in free flaps for war wounds as I gained more experience and when I used the compartment concept to choose the recipient vessels, in our series the time elapsed from the injury and the final surgical treatment was not an important factor in this improvement.

THE SURGERY NEEDED

The final results are still far from the normality, and the suffering of our patients is not measurable but it is huge. The prevention is the answer in every disease, but what we as physicians could do to prevent the war? What have we done to prevent war? Is it possible to prevent war a disease? The ironic issue is how the human being has been able to control diseases that killed our forebears in millions –plague, cholera and typhus-, but not war. The etiology of war is the human being by itself, and should be easier to cure it. The war as disease has mutated faster than the efforts to control it, as a matter of fact has been "improved".
The only option is the education of our children in a non-violent culture, respecting the others and thinking in their needs. Just after several years of suffering and pain the humanity was able to make the Seville Statement (UNESCO) in 1986 **(5)**:
"It is scientifically incorrect to say:

1. That we have inherited a tendency to make war from our animal ancestors.
2. That war and any other violent behavior are genetically programmed into our human nature.
3. That in the course of human evolution there has been a selection for aggressive behavior.
4. That the humans have a "violent brain".
5. That war is caused by instinct."

The origin of war, ten thousand years ago, was the difference of opportunities between agricultural communities in the river valleys with the hunting societies **(6)**, and it is the difference of opportunities the etiology of most the today's conflicts.
Just as wars begin in the minds of men, peace also begins in our minds. The answer is the ***Microsurgery of Our Mind***. The same specie who invented war is capable of inventing peace. The responsibility lies with each of us, as we direct to our children into a culture of non-violence, were the respect and solution of the others needs is our goal.

ACKNOWLEDGEMENTS

Special acknowledgement Dr. Andrew Bamji, curator of the Gillies archives at the Queen Mary's Hospital, who allowed me to visit them and use the pictures presented in this paper.

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5. The Seville Statement. UNESCO. Culture of peace program. 1986.
6. John Keegan. War and our world. Vintage Books a Division of Random House, New York. 1998.

CLINICAL CASES

CLINICAL CASE 1.

Figure 1.

Figure 2.

Figure 3.

Figure 4.

Figure 5.

Figure 6.

Figure 7.

Figure 8.

Figure 9.

Pictures taken with permission form The Gillies Archives, Queen Mary's Hospital, Sidecup,UK.

Figure 1: *Picture of patient taken before his admission, 7th July, 1916.* ***Figure 2:*** *Picture of patient once the wounds had healed by contraction.* ***Figure 3:*** *Diagram made by Henry Tonks showing the design of flaps November 1916.* ***Figure 4:*** *Picture of patient after surgery.* ***Figure 5:*** *Picture after other 3 surgical procedures correcting the eyelid, the results of the nose were considered unsatisfactory, February 1920.* ***Figure 6:*** *Diagram made by Henry Tonks of surgery performed in January, 1921. Lateral flaps were raised and turnover giving the internal lining. The external coverage was done with a frontal flap based in the superficial temporal artery.* ***Figure 7:*** *Picture of the frontal flap in place.* ***Figures 8 and 9****: Final result, May 1921.*

CLINICAL CASE 2.

Figure 1

Figure 2.

Figure 3

Figure 4.

Figure 5.

Figure 6.

Pictures taken with permission form The Gillies Archives, Queen Mary's Hospital, Sidecup,UK.

Figure 1. *Acute wound, 9th September, 1917.* ***Figure 2.*** *Picture once the wound has healed by contraction, 26th October, 1918.* ***Figure 3.*** *An skin tube has been created in the neck, 6th March, 1919.* ***Figure 4.*** *The tube was used to transfer a piece of skin from the upper thorax, to the face, 4th July, 1921.* ***Figure 5.*** *The distal part of the tube is rotated to the nose receiving the irrigation from its attachment to the cheek. 8th November, 1921.* ***Figure 6.*** *Final result once the tissues has been re-arranged in order to cover the maxilla defect.*

CLINICAL CASE 3

Figure 1.

Figure 2.

Figure 3.

Figure 4.

Figure 5.

Figure 6.

Pictures taken with permission form The Gillies Archives, Queen Mary's Hospital, Sidecup,UK.

Figure 1*: Mandible defect secondary to a shotgun wound.* ***Figure 2****: A skin tube has been created; one of the ends has been sutures to the hand which is going to be used as transporter of flap.* ***Figure 3****: After two other surgical procedures the skin tube has been released from the hand and placed in the zone to reconstruct.* ***Figure 4****: Two more tube flaps have been developed.* ***Figure 5****: With tissue of the three tube flaps, modeling of chin starts.* ***Figure 6****: Final result.*

CLINICAL CASE 3.

Figure 1.

Figure 2.

Figure 3.

These pictures were taken with permission to his patients, just for academic purposes by Dr. Luis Bermúdez, MD.

Figures 1 and 2*: Gunshot wound of nose with cartilage lesion and lost of skin coverage.* ***Figure 3****: The lower lateral cartilages are reconstructed using cartilage graft from the ear.* ***Figure 4****: The skin coverage is given by a frontal flap.* ***Figure 5 and 6****: Postoperative views one year after injury.*

CLINICAL CASE 5

Figure 1.

Figure 2.

Figure 3.

Figure 4.

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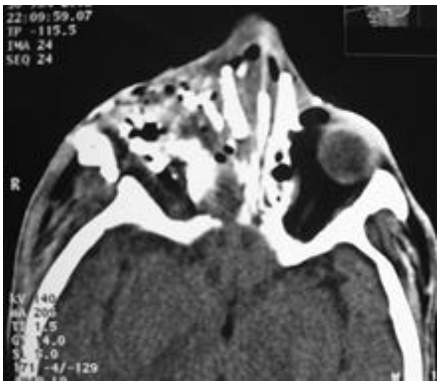
Figure 1 and 2*: Preoperative pictures of patient with tissue expander in the forehead previous to the nasal reconstruction.* ***Figure 3 and 4****: Postoperative views 8 months after the nasal reconstruction following the principle of nasal units.*

CLINICAL CASE 6.

Figure 1.



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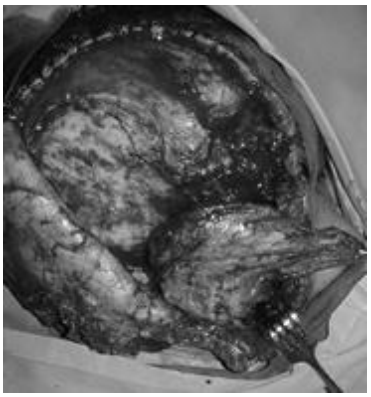

Figure 3.

Figure 4.

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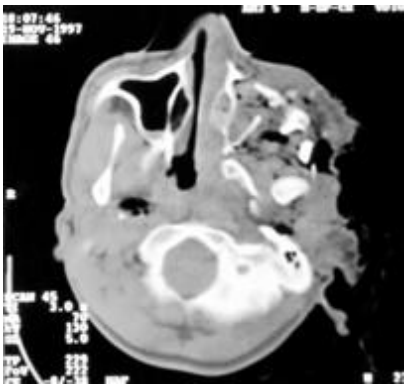
Figure 1*: June 2002, high velocity gunshot wound in right orbit, there is an important dura defect and brain exposure to the maxilla.* ***Figure 2****: CT-Scan showing the destruction of the bony orbit and the eye.* ***Figure 3****: Wide exposure to perform a craniotomy to close the dura. A temporal muscle flap is rotated to fill the exenterated orbit isolating the brain from the maxilla.* ***Figure 4****: September 2002, postoperative result after one surgical procedure, in the acute phase. A defect like the shown in Case 2 was avoided.*

CLINICAL CASE 7

Figure 1.



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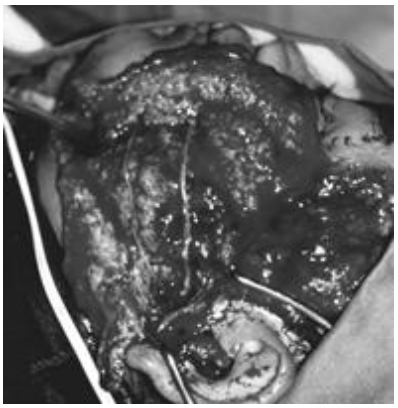

Figure 3.

Figure 4.

Figure 5

Figure 6.

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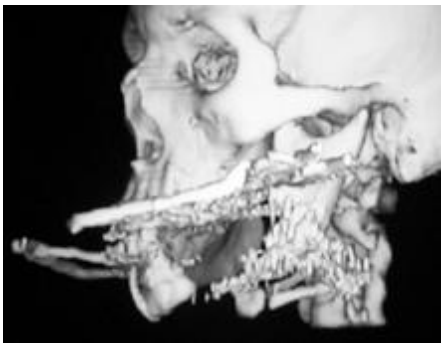
Figure 1*: High velocity gunshot wound in the left face. Severe destruction of parotid gland, facial nerve, temporal muscle, and a skin defect. November 1997.* ***Figure 2****: CT-Scan showing the comminute fracture of the zygomatic bone and arch, as well a mandible fracture.* ***Figure 3****: Once the fractures has been reduced, and a rib graft has been placed to reconstruct the zygomatic arch; a sural nerve graft is done to restore the continuity of the bucal branch of facial nerve.* ***Figure 4****: The skin defect was replaced with a parascapular free flap.* ***Figure 5****: Postoperative picture showing the good projection of the zygoma.* ***Figure 6****: Pictures from a video showing the function achieved after the facial nerve repair.*

CLINICAL CASE 8

Figure 1.



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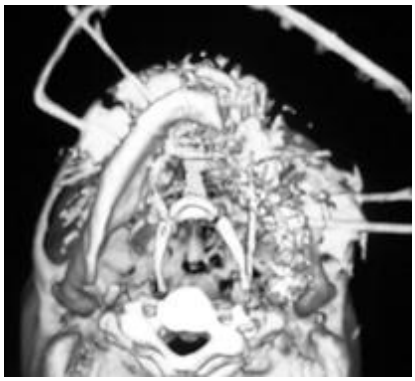

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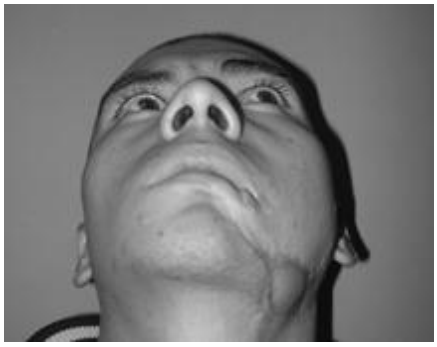

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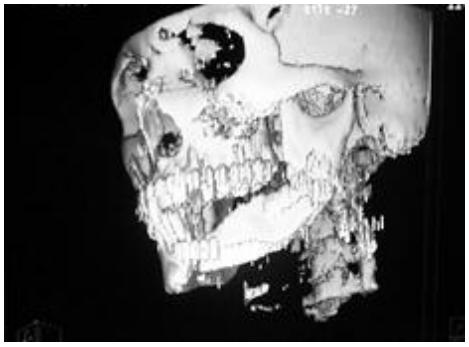

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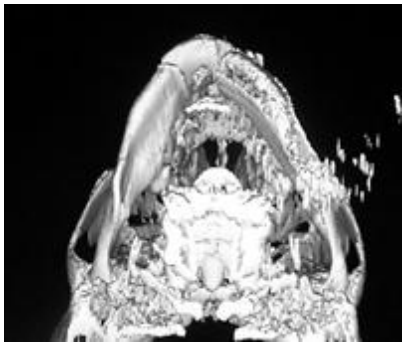

Figure 6

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Figure 1*: Mandible defect caused by a high velocity gunshot wound, the external wire used to fixate the mandible was placed in the site of injury.* ***Figure 2 and 3****: CT-Scan showing the deficiency of bone from the angle to the chin.* ***Figures 4, 5, and 6****: Post operative pictures 2 years later, after mandible reconstruction with an iliac osteocutaneous free flap.*

CLINICAL CASE 9

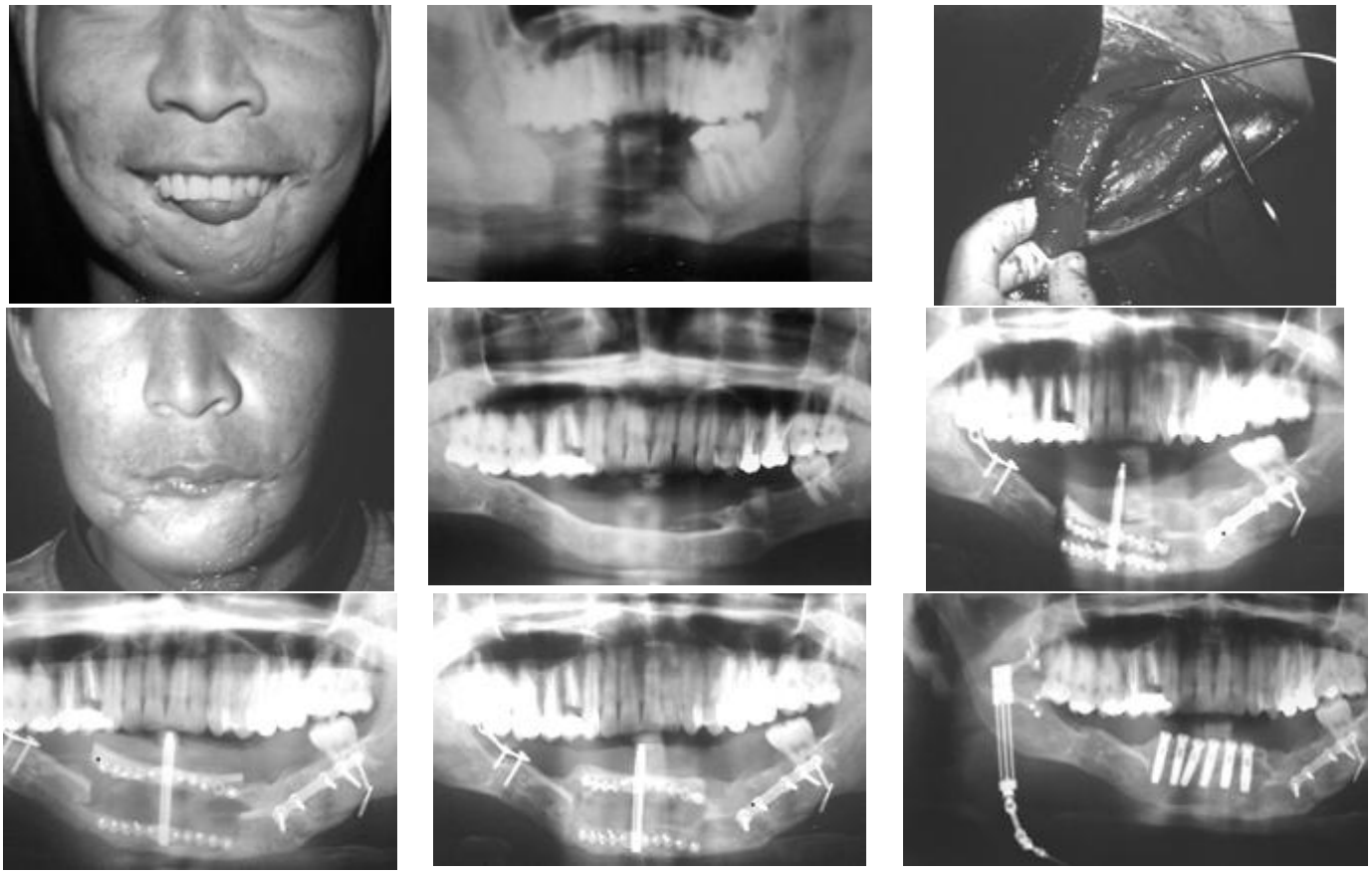

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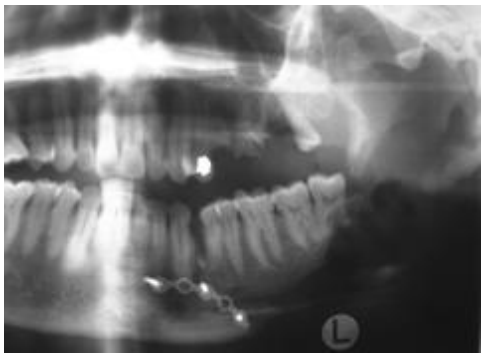
Figure 1*: Patient with an anterior mandible defect caused by a high velocity gunshot wound.* ***Figure 2****: X-rays showing the bone deficiency of the chin and right body of mandible.* ***Figure 3****: A fibula free flap was raised to reconstruct the bone defect; two osteotomies were performed to bend the bone. Picture was taken when the bone was still in the leg.* ***Figure 4****: Postoperative picture of the patient 8 months after surgery, the facial height was restored; the cephalometric menton point is in the right position.* ***Figure 5****: However in the x-rays there is an alveolar deficiency because the fibula is not as wide as the mandible in the chin. The dental rehabilitation of the patient is not possible with this gap between the maxilla and mandible.* ***Figure 6****: An osteotomy and placement of an alveolar distraction device (Martin) is performed.* ***Figure*** *7: X-rays after a 20 millimeters distraction has finished, 30 days later.* ***Figure 8****: X-rays showing the ossification of the distracted bone.* ***Figure 9****: Dental osteointegrated implants are placed by Dr. Hugo Samacá, from the Oral and Maxillofacial Department, the same day I performed another mandible osteotomy and placed a vertical ramus distractor to open a right posterior space in order to fit the dental prosthesis.*

CLINICAL CASE 10

Figure 1.

Figure 2.



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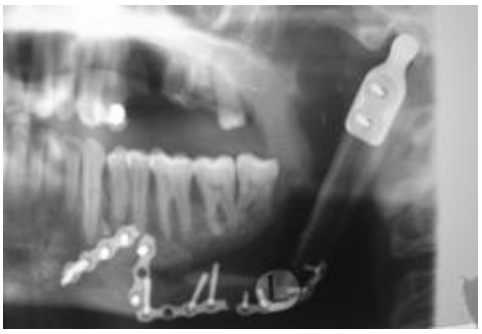

Figure 6.

Figure 7.

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Figure 9.

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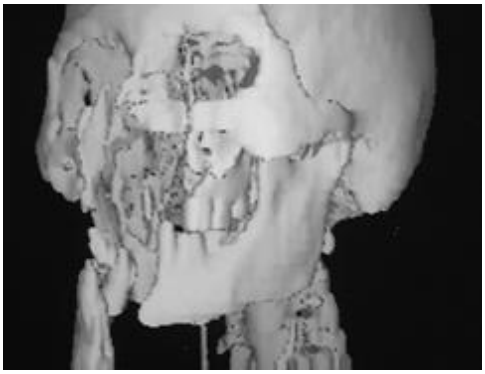
Figure 1,2 and 3*: High velocity gunshot wound in the lateral region of the face, with salivary fistulae, complete lesion of facial nerve, severe lesion of the parotid gland, complete loss of mandible ascending ramus and condyle****. Figure 4****: Fibula free flap with one osteotomy is raised to reconstruct part of the body and the ascending ramus of mandible, condyle prosthesis was placed at the end of the fibula. The skin of the osteocutaneous fibula flap was discharged during surgery because it did not perfuse and was replaced by a radial free flap.* ***Figure 5****: Because the facial nerve was broken at the stylomastoid foramen the ENT surgeon Dr. Jose Prieto, performed a mastoidectomy to find the facial nerve into the temporal bone and a sural nerve graft was used to restore continuity of facial nerve zygomatic branch.* ***Figure 6****: X-rays of mandible, the fibula*

and the condyle implant restored the mandible. ***Figure 7****: The radial free flap died, I think because the recipient vein was the external jugular vein and someone placed a tracheostomy tie in the ICU.* ***Figure 8****: A tissue expander was placed in the neck and a flap was advanced.* ***Figure 9****: Pictures taken from a video showing how the zygomatic branch works.*

CLINICAL CASE 11.

Figure 1.



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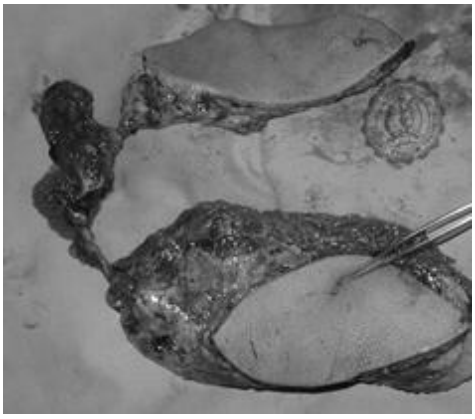

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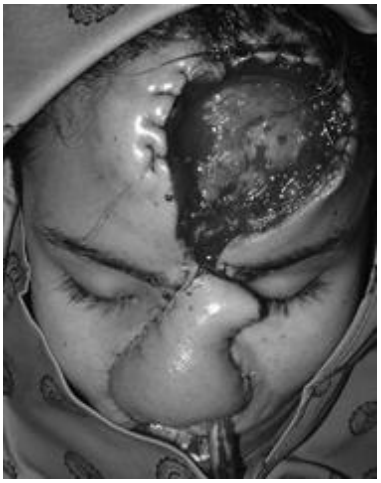

Figure 7.

Figure 8.

Figure 9.

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Figure 1 and 2*: Self inflicted high velocity gunshot wound, admitted in July 2002. The pictures show destruction of the mandible, lips, maxilla and nose.* ***Figure 3****: In the first surgery a composite (bone-skin) parascapular and Latissimus Dorsi free flaps are raised based in a common pedicle (sub-scapular artery). In*

the picture we see the skin (SPS) and bone (BPS) of parascapular, and musclecutaneous Latissimus Dorsi free flap (LD). ***Figure 4****: Conservative debridement and wide exposure of fractures, a reconstruction plate is used to fix the mandible and leaving the bone gap for a second time bone graft.* ***Figure 5****: The free flaps has been transferred using a vein graft, the Latissimus Dorsi (LD) is used to cover the mandible, the bone of parascapular (BPS) to reconstruct the maxilla, and the parascapular skin (SPS) to provide internal and external coverage of nose.* ***Figure 6****: Postoperative view two months after the free flaps surgery; now we have enough tissue to work with.* ***Figure 7****: The external parascapular war taken off and a frontal flap is used to reconstruct the nose.* ***Figure 8****: Upper lip reconstruction.* ***Figure 9****: After lower lip reconstruction, February 2003. There are still several procedures needed.*

CLINICAL CASE 12

Figure 1.

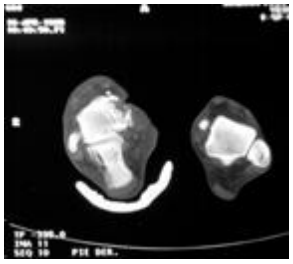

Figure 2.

Figure 3.

Figure 4.

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Figure 1*: Extensive defect caused by a grenade explosion, with open fracture of tibia and medial malleoli.* ***Figure 2****: Leg X-rays and foot CT-Scan, showing the fractures.* ***Figure 3****: Latissimus Dorsi free flap used to cover both fractures.* ***Figure 4****: Postoperative picture 1 year after surgery.*

CLINICAL CASE 13

Figure 1.

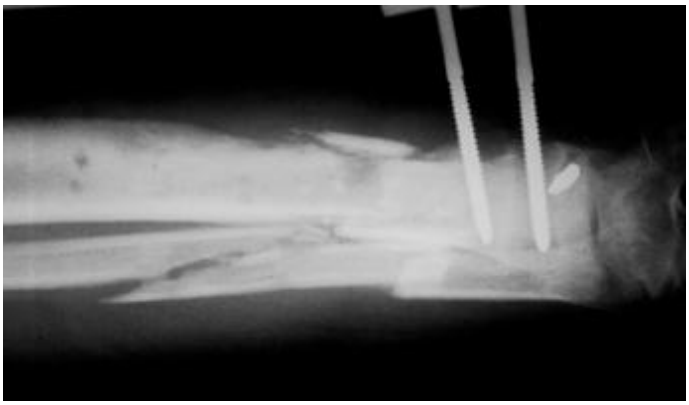

Figure 2

Figure 3.

Figure 4.

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Figure 1*: Anti-personnel mine wounds, left below knee amputation, right open fracture of the lower leg.* ***Figure 2****: X-rays showing the distal right leg fractures.* ***Figure 3****: A Latissimus Dorsi muscle free flap is used to cover the fracture and bone.* ***Figure 4****: Five months postoperative picture.*

CLINICAL CASE 14

Figure 1.

Figure 2.

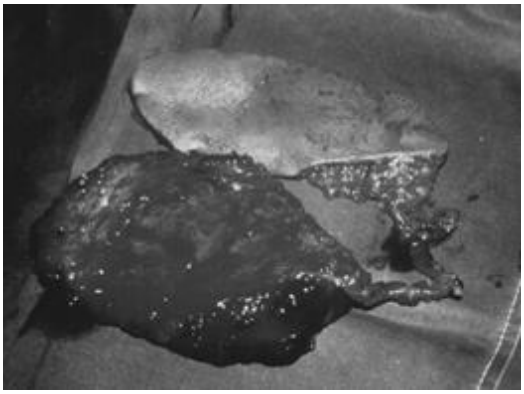

Figure 3.

Figure 4.

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Figure 1*: Anti-personnel mine explosion lesions of lower limbs, the right leg was amputated and the left knee has a complete destruction of the patella and a severe soft tissue defect.* ***Figure 2****: Picture of the stump of the left limb, there was exposure of femoral condyles; the orthopedic surgeons did not want to short the stump, for functional reasons.* ***Figure 3****: In order to cover both fractures, two free flaps were raised based in a common pedicle, parascapular and Latissimus Dorsi. The flap's vessels were anastomosed to the right popliteal artery using the Latissimus to cover the right knee; a cross leg parascapular flap was used to cover the left stump. Figure 4: Three months postoperative picture after releasing the cross leg flap and remodeling it. Parascapular (PS) and Latissimus Dorsi (LD) flaps.*

CLINICAL CASE 15


Figure 1.


Figure 2.


Figure 3.


Figure 4.

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Figure 1 and 2*: High velocity gunshot wound, severe defect of the lateral foot.* ***Figure 3 and 4****: Postoperative pictures 6 months after a Rectus Abdominis muscle free flap and skin grafts.*

CLINICAL CASE 16

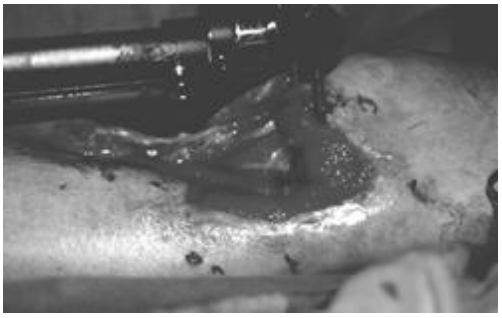

Figure 1.

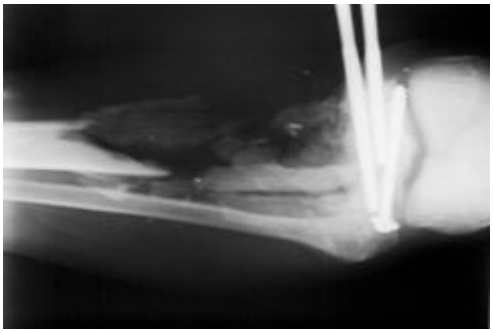

Figure 2.

Figure 3.

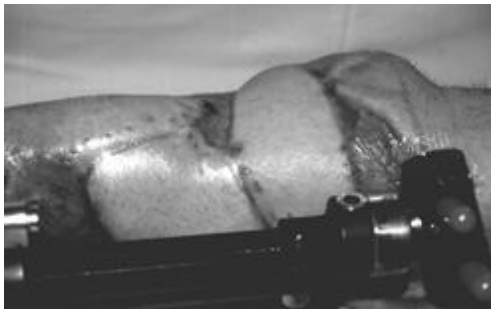

Figure 4.

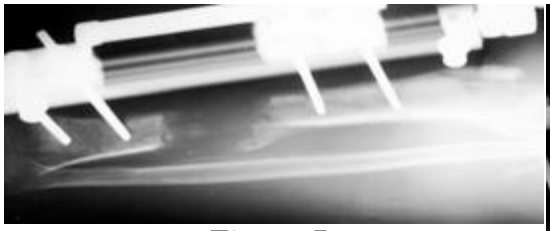

Figure 5.

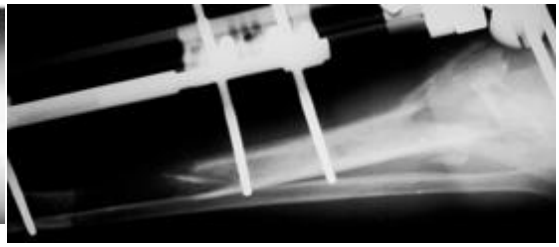

Figure 6.

Figure 7.

Figure 8.

Figure 9.

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Figure 1 and 2*: High velocity gunshot wound of leg and knee.* ***Figure 3****: In order to cover the open fracture and to completely fill the hole avoiding bone infection, a Latissimus Dorsi free flap was performed, using popliteal vessels as recipients.* ***Figure 4****: Postoperative picture of the free flap (FF) and a local fasciocutaneous flap (FC).* ***Figure 5 and 6****: Bone defect was reconstructed (By Dr. Carlos Satisabal, from the Orthopedic Department) using bone transport and osteogenesis distraction. In figure 5 we see the distal osteotomy completely distracted and in figure 6 we see how the bone was moved upwards.* ***Figure 7, 8, and 9****: Postoperative pictures showing the function, 18 months after free flap.*