AN APPLICATION OF AUTOGENOUS CANCELLOUS BONE GRAFTING IN BONE DEFECTS TO THE WAR WOUND
PRIMJENA RANE AUTOGENE SPONGIOPLASTIKE KOD KOŠTANIH DEFEKATA RATNE RANE

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Summary :

The study investigates possibility of an early cancellous bone grafting in treatment of the war wounds caused by a high velocity projectile or shrapnel.

Two groups have been evaluated, group A with an early cancellous bone grafting and a control group B with a secondary cancellous bone grafting. An average size of the bone defects was 2.01cm, whilst primary stabilization of the bone defects was performed by the means of an external fixator. The iliac crest was a donor site for an autogenous bone graft in all cases. Out of 18 cases of the investigated group, 14 achieved a complete bone consolidation. In comparison to the secondary cancellous bone grafting, an early cancellous bone grafting decreases the treatment for three months in average and number of surgeries for 1,2.

Key words: War wound, bone defect, bone grafting, primary bone grafting in war wounds.

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REZIME

U radu se ispituje mogućnost rane spongioplastike kod liječenja ranjenika projektilom ili gelerom velike početne brzine. Obrađene su dvije grupe, ispitivana grupa A sa ranom i kontrolna grupa B sa sekundarnom spongioplastikom. Veličina prosječnog koštanog defekta bila je 2,01 cm, a primarna stabilizacija koštanih fragmenata urađena je sa spoljnjim fiksaterom. U svim slučajevima donatorsko mjesto autotransplantata bila je krista iliaka

Kod ispitivane grupe, od 18 slučajeva kod 14 je došlo do potpune koštane sanacije. Ranom spongioplastikom liječenje se u prosjeku završava tri mjeseca ranije u odnosu na sekundarnu spongioplastiku, dok se broj hirurških zahvata prosječno se smanjuje za 1,2.
Kljune riječi: Ratna rana, koštani defekt, koštana autotransplantacija, primarna koštana autotransplantacija ratne rane.

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Introduction

A war wound is defined as a bodily injury caused by a firearm. It is characterized by extensive tissue damage and primary polymicrobial contamination. They are caused missiles of high initial velocity or shrapnel. [1,2,3.]

The amount of devitalized bone in fragments is determined by the damage of the periosteal and endosteal blood vessels as well as number of dead osteocytes. Devitalization of osteocytes in the diaphyseal region is about 1-2 mm while in the metaphyseal region about 2-5mm in proximal and distal fragments of the fracture site [2,3,4,5.]. Bone defects in gun shot fractures are formed as a result of removing of the free bone fragments and dissection of the devitalized bone fragments in primary or secondary surgical management.(Fig.1) During the surgical management of the bone tissue it is difficult to estimate vitality of the bone fragments since there are no exact indicators for the intraoperative estimation. The usual indicators are as follows: Bleeding from the exposed ends of the bone, periosteal condition of the bone fragments and size of the bone fragments. [6,7,8.] Function of the limb is not only damaged in diaphyseal defects or defect of the whole circumference but also in significant defects of the bone ends which deprives the stability of the bone as well. [9,10,11]

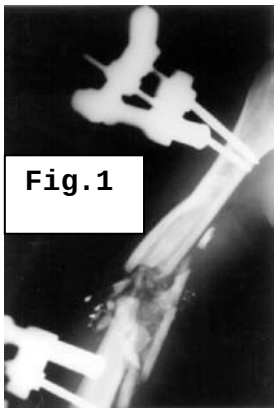
Fig.1

The bone grafting understands a procedure of removing of a part of a bone from a donor site to a recipient site in one person (autogenous graft) from one person to another (allografts) or from one to another species (heterograft) [10,12,13,14.].

A choice of a method for the reconstruction of a bone defect depends on the following parameters: vascularity of the transplantation site, stability of the transplantation as well as of a cause and size of a bone defect[15,16].

The bone grafts may function as a source of osteogenesis from donor cells that survive a transfer and mechanically support the site of a cortical defect[17,18.].

Incorporation of a bone graft follows the same sequences as fracture healing. This process includes induction, inflammation, soft callus formation, hard callus formation and remodeling. Many of those sequences can be present in the same time at the different sites in extensive bone grafts. Autogenous bone grafts are defined according to the type of the bone such as cancellous grafts, cortical grafts, cancellous-cortical grafts and vascularized bone grafts[9,15].

Diagnosis of the bone defects is determined according to the medical history, clinical examination and standard x-rays of long bones in two projections. Clinical examination during the surgical management gives the most accurate data about bone defect.

Aim

An early autogenous cancellous bone grafting (primary cancellous bone grafting) in bone defects to the war wound is more efficient than the secondary cancellous bone grafting since there are less surgical procedures and shorter time of treatment.

Methods and material

Investigated group - group A, consisted of 18 men with bone defects after wounding by high velocity missiles or shrapnel. Restoration of bone defects up to 5 cm with cortico-cancellous grafts was performed during the primary surgery (up to 15 days) simultaneously with delayed primary closure.

Control group – group B, consisted of 22 men with bone defects after wounding by high velocity missiles or shrapnel. Restoration of bone defects was performed after three or more months after the primary surgical management (secondary cancellous bone grafting)

All of the wounded underwent primary surgical management within six hours from the moment of wounding. All fractures were situated in the diaphyseal region. Upon the admission all patients received anti-tetanus protection and crystal penicillin 4 dosages of 5MIU intravenously and Gentamicine 2 doses of 80 mg. Diagnosis was established according to preoperative x-rays and on the operating table. After the primary surgical management one could obtain exact data about the size of a bone defect. A donor site was determined according to the size of a bone defect. A look of a wound, smear taken on the eight day and laboratory findings such as ERs, complete blood count and leukocyte formula were the parameters for estimation of infection and decision about the day of surgery. All patients were treated on the Orthopaedic and Trauma surgery Clinic in Banjaluka. Surgical procedures in group A were undertaken after obtaining the optimal conditions. Working pattern was as follows: Preparing and draping of both the site of a bone defect and donor site. Preparing of the recipient site for grafting. Excochleation of the wound, skin refreshment and rinsing of the excochleated tissue with normal saline as well as control of haemostasis at the same time.

Gauze soaked with normal saline solution and then wring out and covered with dry gauze is placed in recipient site prepared in a described manner. From the donor site determined upon a size of a bone defect a cancellous bone graft is taken in size up to 1 cm^3 and cortico-cancellous bone graft according to Phemister.

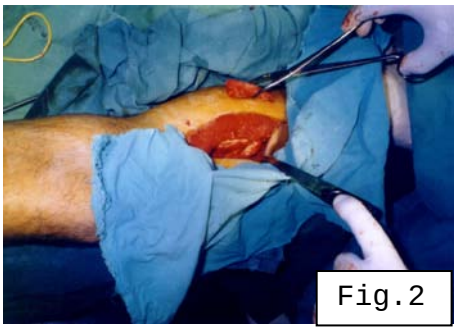

Fig.2

Such work pattern enables the least exposition of osteocytes from autogenous bone graft that to different non-physiological conditions. It is necessary to obtain a sufficient quantity of autogenous graft harvested from a donor site in non-traumatic fashion. A bone defect is grafted and a wound closed in layers. Bone graft was covered with well-vascularized muscular tissue, and when that was not possible it was covered with vital skin. After the grafting a donor site was closed in layers and drained.

Physical therapy (static motions of the operated limb) was undertaken in bed on the first postoperative day.

Walking with armpit crutches, depending on a size and stability of a bone graft, was carried out already on the third postoperative day. A decision on walking without weight bearing, minimal weight bearing or weight bearing from 5-10kg depended on a size of a bone defect and stability of bone fragment

After healing of a surgical wound patient were sent to home treatment. The first check up with x-ray was undertaken after 6 weeks. Patient or a family member (educated on the Clinic by a physiotherapist) usually performed kinezy or hydrotherapy at home.

Clinical check ups until the first radiography was undertaken every 15 days after the delayed cancellous bone grafting. Clinical check ups enabled follow up of the dynamics of soft tissue healing as well as hygienic conditions around pins to the external fixator. Subsequent radiographic check ups on the thirtieth day enabled evaluation of fracture healing and rate of weight bearing as well as the full usage of he limb.

Results

Obtained data are numerical discontinuated marks given as single or grouped as classes, with unequal class intervals.

For description of the investigated phenomena we used mean values, standard deviation, and variable coefficient.

The same phenomena were compared in both groups of patients and significance of difference was established by F-test. The results of research of initial and final conditions were compared in groups A and B. At the end we investigated presence and degree of relation of different parameters in investigated group.

Statistical evaluation was done in MS Excel program.

The evaluation consisted of data obtained from the history of disease and surgical protocol, time from wounding until the primary surgical management, cause of injury, size of a bone defect, time of restoration of a bone defect, number of surgeries, time of bone consolidation, time of treatment, complications during the treatment, delayed union, pseudoarthrosis, infection, contractures, bone abbreviation after the consolidation.

Radiological evaluation understood elaboration of the initial and control x-rays of the bone defects in long bones.

Evaluation of the final results is presented in the following table:

	Result	
Indicator	Good	Bad
Number of surgeries	Achieved bone union	Did not achieve bone union
Time of hospitalization	Minimal time	Maximal time
Complications	None	Present
Pseudoarthrosis	None	Present
Joint contracture	None	Present
Limb abbreviation	None	Present

Average age in group A that underwent primary cancellous bone grafting was 29,77 years. The oldest patient was 42 and the youngest 19 years old.

An average age of patients in group B, who underwent secondary cancellous bone grafting, was 27,72 years. The oldest was 38 and the youngest was 19 years. All patients were male.

Primary wound management in investigated group was performed in average time of 5,53 hours from the moment of wounding, while in control group it was performed in average time of 5,41 hours.

After analyzing the time of the primary wound management we concluded that it has no influence on the final result of treatment in one of the observed groups. An average size of the bone defect in-group A after the wounding and primary wound management was 2,01cm. The biggest bone defect was 3,5 cm and the smallest one was 1cm. An average size of the bone defect in-group B was 3,38 cm. The difference in size of bone defects was tested in both groups using F-test. It was established that there is no statistically significant difference in size of the bone defects in the primary or secondary cancellous bone grafting.

A restoration of a bone defect in group A was performed in average time of 12,22 days after the primary wound management. The earliest bone grafting was performed on the ninth day and the latest one on the fifteenth day after the primary wound management. A bone grafting in-group B was performed in average time of 3,93 months or 117,9 days after the primary wound management. We come to a conclusion that there is a statistically significant difference in two analyzed procedures in the sense of timely dependent bone grafting (Chart 1). Difference in time of bone grafting shows the advantage to the primary cancellous bone grafting. An average number of surgical procedures in-group A was 2,2 and 3,4 in group B.

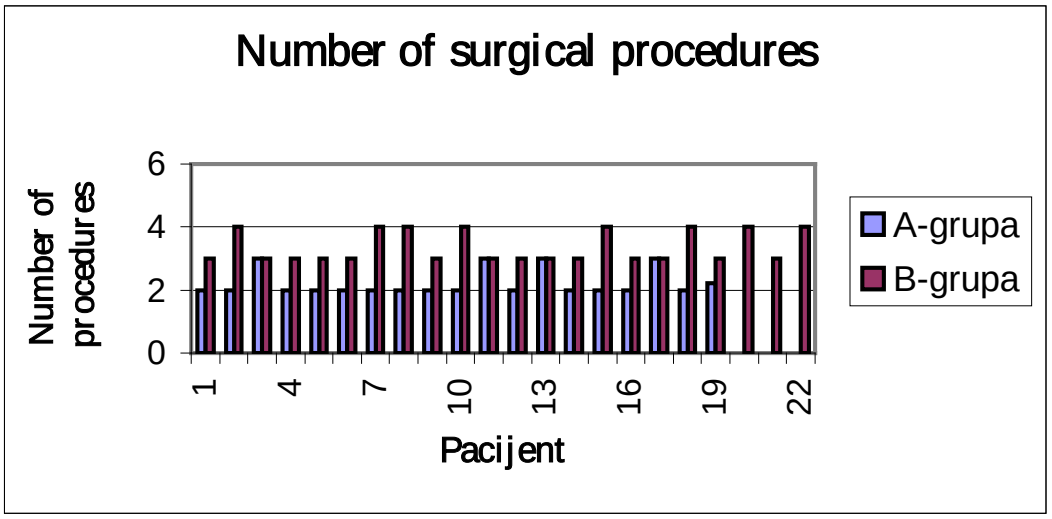

Chart 1. Time of the bone grafting

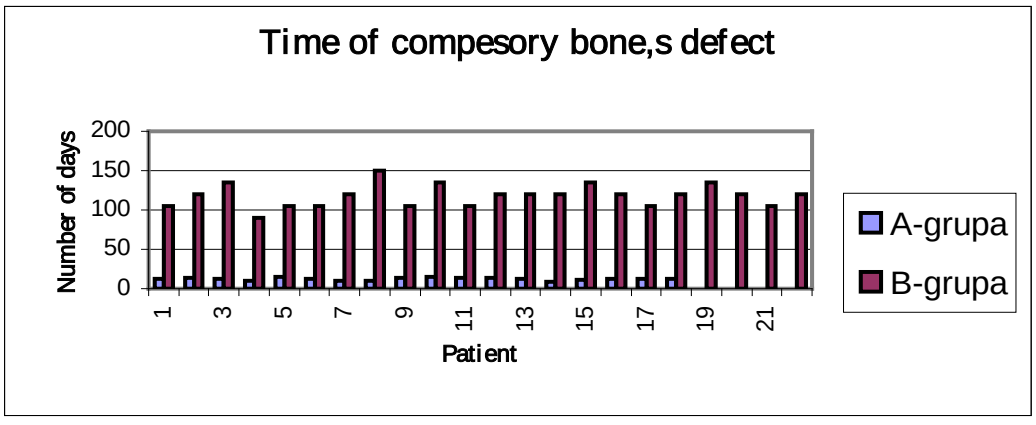

Chart 2. Number of surgical procedures in investigated and control groups

F-test showed that there were significantly less surgical procedures in-group A in comparison to the group B due to the efficiency of the primary cancellous bone grafting.

Time of treatment understands time from wounding to primary wound management, time from primary wound management to cancellous bone grafting, and time needed for bone consolidation after cancellous bone grafting.

An average time of treatment in-group A was 411,53 days. This time includes time from wounding to primary wound management (an average time was 5,52 hours), time from primary wound management to cancellous bone grafting (an average time was 12,22 days), time needed for bone consolidation after cancellous bone grafting (an average time was 13,3 months).

An average time of treatment in-group B was 703,13 days. This time includes: time from wounding to primary wound management (an average time was 5,4 hours), time from primary wound management to secondary cancellous bone grafting (an average time was 3,93 months), time needed for bone consolidation after secondary cancellous bone grafting (an average time was 19,5 months).

F-test showed that there was significant difference in times of hospitalization between group A and group B in favor of primary cancellous bone grafting.

In-group A an external fixator was final solution in 14 cases, whilst in four cases I used distarctive osteogenesis (tibia), re-osteoplasty and AO plate. In three out of 18 cases autogenous bone graft was harvested from both iliac crests.

In-group B bone defect was treated autogenous bone graft harvested from the iliac crest and stabilization was performed with AO plate. The complications that were followed up were as follows: nonunion (pseudoarthrosis), infections, and pin track infections, joint contractures abbreviations of the limbs and neurovascular disorders.

Complications in-group A were as follows:

	COMPLICATIONS	
	NUMBER OF COMPLICATIONS	HEALED WITHOUT COMPLICATIONS
Pseudoarthrosis	4 (22,24%)	14
Pin track infections	4 (22,24%)	14
Joint contractures	5 (37,79%)	13
Limb abbreviations	4 (22,24%)	14
Neurovascular disorders	None	18

Complications in-group B were as follows:

	COMPLICATIONS	
	NUMBER OF COMPLICATIONS	HEALED WITHOUT COMPLICATIONS
Pseudoarthrosis	4 (22,24%)	18
Pin track infections	None	22
Joint contractures	8	14
Limb abbreviations	4	18

Neurovascular disorders	None	22

Statistic analysis of age, cause of injury, primary surgical management, size of a bone defect, time for restoration of bone defect, stabilization of bone fragments and complications and comparison of their mean values, standard deviations and coefficient of variation as well as testing with F-test showed that there are no significant differences between group A and B in relation to seven analyzed parameters. Statistic analysis of time of healing and number of surgical procedures showed a statistically significant difference between groups A and B, in favor of group A.

Discussion

The concept of primary repair and reconstruction of all tissues damaged in trauma introduced drastic changes to the conventional treatment in the last two decades. Supporters of an early reconstruction of the soft tissue injuries (Kleinart, Janzekovic, and Godina) showed great functional and esthetic results.

Results of treatment of open fractures primarily depend on treatment of combined soft tissue injuries. An adequate soft tissue coverage and revascularization will provide the best conditions for incorporation of a bone graft and subsequent bone formation. It is of a vital importance to undertake bone grafting after these conditions are met. [2,13,14,18.,] A cancellous bone grafting will give good results when the recipient site is well vascularized and it is recommended to avoid unnecessary delay of cancellous bone grafting. [9,10,15.]

A cancellous bone grafting of type II and III fractures can be performed in the second week after soft tissue coverage using skin graft or a local muscle flap. In type III fractures that request bigger soft tissue reconstruction using free tissue transfer it is recommended to delay cancellous bone grafting for 4-6 weeks after the soft tissue reconstruction. [2,7,9,12,17,] Insisting on such approach lays in uncertainty that a good debridement that was performed and that it is needed to perform additional debridement in high-energy injuries. A great number of authors recommend re-excision of a war wound within 24-48 hours, since it is difficult to make precise estimation of a tissue vitality at the time of a primary excision. [6,9,14.]

In his experimental research Albreht found out that local administration of antibiotics up to three hours after injury might delay primary wound management up to 72 hours without increase of a rate of local infection. Jackson came up with the similar results during the Falkland war. He commenced administration of antibiotics in period of six hours after wounding. Results showed no septic complications when administered antibiotics up to three hours after the wounding since they inhibit bacterial growth in gun shots. [6,12]

Karapetjen and Petrov who treated 1361 patients with gun shot fractures of the long bones in Angola, accepted the opinion that it is possible to perform an internal osteosynthesis with previous administration of antibiotics. Beside an internal such osteosynthesis they performed osteoplasty with bone grafts from the tibia and fibula in 17 patients after 21 days. Result of treatment was satisfactory in 11 patients and bad in 8 patients.

In 1980 Popkirov used a quality of resistance of the cancellous bone to infection and performed plasty of osteomyelitic defects with cancellous bone chips leaving the wound open. He called this method an open cancellous bone grafting.

Gricanov et al. on the experiences from the Afghanistan war gives advantage to external fixator, forcing the compressive and distractive external fixators with hinged joints. In 1994 Jovanovic Z. Popovic Z. et al. submit criteria for treatment of bone defects in long bones with autogenous bone grafts and stabilization of bone fragments with compressive AO plates. They present experience in treatment of 129 diaphyseal gunshot fractures. Conditions for application of this method are as follows: a good soft tissue coverage, absence of clinical and laboratory signs of infection, and bone defects lesser than 4 cm. Bone consolidation was achieved in 123 (95,4%) cases, with average time of union of 6,9 months. Postoperative infection developed in 10 (7,8%) patients.

It is generally accepted that one can assume a cancellous bone grafting will give satisfactory result if a bone defect is 6cm or lesser and a soft tissue coverage good. (Maurer and Dillin, 1987, Blick and al. 1989, Meister and al. 1990.)In-group A, with application of an early cancellous bone grafting a functional result was good in 14 (77,76%) cases. In 4 (22,24%) cases there was no union and the result was presented as bad. Localization of non-unions was in distal third of the tibia (2 cases), ulna and femur. A size of a bone defect of pseudoarthrosis was more than 3,8 cm, and autogenous bone graft was harvested from the iliac crest.

Conclusion

The intention of gunshot fractures treatment is to prevent infection and to achieve union as well as full restoration of functions and esthetics of the limb.

A primary wound management doctrine is understood and accepted. A plaster of Paris immobilization, until this war the most usual method for stabilization of bone fragments after primary wound management and transosseal traction, give way to external fixation. A rigid osteosynthesis using AO plate and simultaneous cancellous bone grafting was tested in many cases in secondary treatment as well as in this War and was proved very successful too. The basic conditions for application of this method are finalization of the first phase and lack of the clinical and laboratory signs of infection. Supporters of an early reconstruction of the soft tissue injuries showed great functional and esthetic results and emphasized importance of an adequate vascularization in order to have better control of postoperative infection. The problem of an early cancellous bone grafting is not sufficiently published in literature. Beside that, lack of possibility to follow up the same parameters in time as well as in the same conditions and place of work provides more difficulties in research of application of an early cancellous bone grafting to the war wound.

Never the less, application of early cancellous bone grafting in bone defects in war wounds proved to be possible and successful in primary phase of treatment. It can be used if the following conditions are met:

The essential conditions for the satisfactory results in treatment of bone defects with autogenous cancellous bone graft are as follows:

1. Primary wound management according to the surgical doctrine;
2. An adequate stabilization of bone fragments with external fixator;
3. Bone defect should not exceed 5 cm in size
4. Lack of clinical and laboratory parameters of infection;

5. Autogenous bone graft should be covered with vital soft tissue (musculocutanuous or full skin) after primary delayed or secondary wound closure;
6. Good co-operation from the wounded, adequate and well timed physical therapy;
7. Diaphyseal gunshot fracture with bone defect treated with autogenous bone graft in the primary phase- shows signs of union.

Testing the time of bone consolidation, incorporation of autogenous bone graft in the primary and secondary cancellous bone grafting did not show statistically significant difference between the investigated and controlled groups. The time of treatment of patients using early cancellous bone grafting is shorter just for the delay in for the secondary cancellous bone grafting (3,93 months). Early cancellous bone grafting avoids one surgery in average for the wounded. Knowledge gained during the research and experiences in treatment of gunshot fractures (with or without bone defects) provide good conditions for application of early cancellous bone grafting in partial and full bone defects up to5 cm in size.

References

1. Arata M.A., Wood M.B., and Cooney III, M.P. (1984) Revascularizd segmental diaphyseal bone transfer in the canine: An analysis of viability, J.Reconstr. Microsurg.,1,11-19
2. Aronson J., Johnson E. and Harp J.H. (1989) Local bone transplantation for treatment of intercalar defects by the Ilizarov technique, Clin. Orthop., 243, 71-79.
3. Burri C., and Stober R., (1987)., Knochentransplantation bei der posttraumatischen Ostetis. In: Wolter D. and Jungbluth K.-H. (Eds) Wissenschaftliche und klinische Aspecte der Knochentransplantation, Hefte Unfallheilkunde, Heft 185, Springer Berlin Heidelberg, pp 240-247.
4. Betz A., Baumgart R., Hierner R. et al., (1991), Der programmierbare Marknagel zur Extremitaten verlangerung und Segmenttverschiebung mittels Kallusdistraction. Hefte zur Unfallheilkunde, (submitted 1991).
5. De Boer H. H. (1988) Vascularized fibular transfer, Thesis, Leiden, Netherlands
6. Grubor P. Mitkovi} M., Application of Mitkovic external fixation in treatmant of war wounds of anatomic and surgical neck of the humerus, XII International Congress of emergency surgery and intensive care, Oslo. 1995, 73-74.
7. Grubor P. Mitković M., Polyvalent application of the Mitkovic external fixator in war and peacetime trauma, XII International congress of Surgery and intensive care, Oslo 1995, 74-75.
8. Grubor P., Mitkovic external fixator in war wounds of the femur, SICOT 96, Amsterdam, 89-98.
9. Grubor P., Mitkovic external fixator in trauma of the pelvis; SICOT 96, Amsterdam 89,90.
10. Grubor P., A rational treatment of the war wound of the lower leg using Mitkovich fixator and Sarmiento' s cast, 2nd Central European Congress, Budapest, 1998, ARTOF, 76-77.
11. Grubor P., Uloga spoljne fiksacije u zbrinjavanju ratne rane,1996, Glas Srpski
12. Grubor P., Tretman koštanog defekta, 1999,Glas Srpski

13. Grubor P., Primjena rane autogene spongioplastike kod koštanih defekata ratne rane , Magistarski rad, Banja Luka 1999.
14. Kojić V. Siniša: Slobodni mikrovaskularni režanj u rekonstrukciji ratnih defekata skeleta , Magisterska teza , Beograd 1996.
15. Marakas Zlatko, Radiologija, Naučna knjiga, Beograd, 1978.
16. Meeder P. J., Ch. Eggers, Biological principles of autogenous bone grafting Journal of Spinal Disorders, Vol. 7. No3 216-221 (1994)
17. Mitchel B Harris, Jochan Davis and Stanley DGertzbein, Iliac Crest Reconstruction After Tricortical Graft Harvesting, Journal of Spinal Disorders, Vol.7 No.3pp 221-229. (1994)
18. Sarmiento A., (1990), Personal communication, Munchen, Octobar 1990.