Acta Ortopédica Mexicana

Volumen 19 Supl. 1 Mayo-Junio 2005
Volume Suppl. May-June

Artículo:

Treatment of forearm nonunion with iliac crest graft and a Hunec nail

Acta Ortopédica Mexicana 2005; 19(Suppl. 1): May.-Jun: S28-S33

Original article

Treatment of forearm nonunion with iliac crest graft and a Hunec nail

Edgardo Arredondo-Gómez*

"Ignacio García Téllez" National Medical Center, IMSS

SUMMARY. Forearm bone loss is usually the result of high-energy trauma or complications or failures in managing simple fractures. *Material and methods*: a total of 38 patients were reviewed, with 44 lesions diagnosed as forearm bone loss resulting from nonunion, both aseptic and infected, where a Hunec nail was used as an implant and the defects were replaced with iliac crest fragments. The bones involved included 26 ulnas and 18 radii; they had been managed with previous surgical procedures, most of them with plates as implants. Infected cases were treated following the Colchero protocol. Iliac crest fragments were used to replace the bone defects ranging from 3 to 7.5 cm in length, with an average of 5.2 cm, and a Hunec nail was inserted as an implant. *Results*: the mean operative time was about 90 minutes. Except for 4 cases, all lesions healed within approximately 16 weeks. Combining an implant that provides optimum stability with a mean osteogenic supply rapidly integrating and geometrically adapting to the forearm bone shaft highlights the method advantages.

Key words: forearm, intramedullary nail, bone loss.

RESUMEN. Las pérdidas óseas en el antebrazo suelen ser resultado de traumatismos de alta energía o derivarse de complicaciones o fallas en el manejo de fracturas simples. *Material y métodos*: Se revisó un total de 38 pacientes con 44 lesiones diagnosticadas como pérdidas óseas en antebrazo derivadas de seudoartrosis tanto asépticas como infectadas, en las que se empleó el clavo Hunec como implante, reemplazando los defectos con tramos de cresta ilíaca. Veintiséis cúbitos y 18 radios, todos con procedimientos quirúrgicos previos en su mayoría manejados con placas como implantes. Los casos infectados se trataron con el protocolo propuesto por Colchero. Para sustituir los defectos óseos que fueron de 3 a 7.5 cm con un promedio de 5.2 cm se emplearon tramos de cresta ilíaca, y se utilizó el clavo Hunec como implante. *Resultados*: Se tuvo un tiempo quirúrgico de aproximadamente 90 minutos. Exceptuando cuatro casos, todas las lesiones consolidaron en un período aproximado de 16 semanas. Se destacan las ventajas del método al combinar un implante que proporciona estabilidad óptima con un medio de aporte osteogénico de rápida integración y adaptación geométrica a la diáfisis de los huesos del antebrazo.

Palabras clave: antebrazo, clavo intramedular, pérdida ósea.

Introduction

Treating forearm bone loss is usually a problem. Although it may be the result of high-energy trauma with massive loss of tissue (as is the case of gunshot wounds), it is often a complication of complex fractures or fractures inappropriately managed initially. In both cases the blood-supply status of soft tissues plays a significant role in the final treatment. Under different circumstances, the complication may derive from failure of the implant or the surgical technique. A poor placement in safe procedures, such as plate misplacement, usually leads to complications. Ac-

* Assistant Professor and Staff Physician, Orthopedics and Trauma Service of the "Ignacio García Téllez" National Medical Center of IMSS.

Mailing address:
Dr. Edgardo Arredondo-Gómez. Calle 57 x 54 # 474-C. Centro. Mérida, Yucatán. CP 97000. Telephone: 01 (999) 924-91-33.
Fax: 01 (999) 924-08-70. E-mail: arredondo@cablered.net.mx

cordingly, Tauber[1] states that instability due to improper internal fixation is the cause of nonunion in 15 cases treated with plates. Caden[2] agrees with Tauber and reported complications in 40% of patients when an insufficient number of four-hole plates was used.

When rigid fixation of plates is lost, plastic and repetitive mega-motion at the fracture focus inevitably leads to implant loosening because of mechanical prompting. Colchero showed that this plastic mega-motion might be so significant that it ends by causing lysis of the cortical bone supporting the plate, obliteration of the spinal canal and, in extreme cases, full-ring destruction of a shaft segment. This bone necrosis, more evident when the plate is removed, may be even greater in the presence of added septic processes *(Figure 1)*.[3]

Several techniques have been reported in treating forearm bone loss. Boyd recommends the use of a cortical tibial graft fixed with screws to restore bone continuity.[4] Grafts using ulnar segments held by screws were reported by Miller and Phalen.[5] Spira was the first to insert an iliac crest segment by means of intramedullary nailing.[6] Dabezies, Grace and Eversman used iliac crest segments and plates to bridge the defect in patients with severe firearm wounds.[7,8] Moroni modified this technique and used a piece of fibula as a bridge with a plate fixated contralateral to a tibial cortical graft in a group of patients with bone loss, with good results.[9] Most of these bone losses had resulted from improper surgical techniques.

The use of vascularized fibula and iliac crest associated to different implants has been widely accepted. There are very few reports of bone migration in the forearm as proposed by Ilizarov, compared to the experience with the pelvic limb.

The purpose of our study was to assess the result of nonunion with radial and ulnar bone loss using an iliac crest graft as a segment and the Hunec nail as an implant.

Material and methods

The study covers the period between December 1991 and January 2003 and included patients initially treated at the "Benito Juárez" Hospital (1991-1995) and the IMSS (Spanish acronym for Mexican Social Security Institute) "Lic. Ignacio García Téllez" National Medical Center located in Mérida, Yucatán (1995-2003), regardless of age, gender, occurrence of sepsis or prior surgical procedures.

A total of 38 patients with 44 lesions involving bone loss were studied. All patients were diagnosed as having nonunion.

All cases had undergone prior surgery, with 15 patients having had more than two surgeries, including the placement of the bone graft. Steinman nails had been used in three patients and one patient required external fixation. The other patients had plates implanted: 12 plates were half the size of the long bones; ten plates were 1/3 the size of the long bones; twelve 3.5 DCP plates; and six 4.5 DCP plates. Sepsis was found in 16 cases. Twenty-six injuries involved the ulna and eighteen involved the radius. Twenty patients had been diagnosed initially with fracture of both forearm bones and 18 of one bone only. The series included ten female patients and 28 male patients. The average age was 38.2 years (ranges between 18 and 69 years). Injuries resulted from motor vehicle accidents in 18 cases; labor activities in 9; sports activities in 4, falls in 5; and 2 were gunshot wounds. Iliac crest segments, 3 to 7.5 cm in length, were used. The average length was 5.2 cm.

The Hunec nail was used and bone defects were filled with an iliac crest graft we call a "segment" *(Figure 2)*. We used a brachiopalmar splint until the suture material was removed, about 10 days later. In patients with infection, Colchero's sepsis eradication method[10] was first used.

Patients were followed up in the respective outpatient services with periodical radiographic controls until healing of the injury. All cases were treated on a one on one basis.

Results

The follow-up period was 5 to 24 months, with a mean of 18.2 months. The injuries healed within 13 to 20 weeks (mean of 16.5). Four cases were considered as failures because of nonunion and activation of sepsis in two of them. Five patients were subject to the Sauvé-Kapandji-type plasty due to distal radioulnar instability as a result of previous dislocations. One patient developed tendonitis of the extensor pollicis longus muscle due to prominence of the nail at the anatomical line, which resolved when the implant was removed. Mobility was recovered by all patients, except for a significant reduction in the range of pronation-supination seen in five patients. The usual time for patients to return to their activities was about 4 to 9 months. The osteosynthesis material was removed after two years in 10 patients. Moderate-to-intense postoperative pain at the graft harvest site was the most common complication.

Discussion

Except for two cases secondary to gunshot wounds, all patients were treated for nonunions resulting from fractures subject to prior surgical procedures in which most implants were plates. Using a bone segment on a plate resulted in radiographic and histological bone loss. Wolf's law initially explained this. However, later AO studies have shown they result from vascular damage and the presence of the implant itself thus generating a transient phase of intense remodeling. This occurs less frequently with the more recent, minimum contact implants. Nonetheless, implant loosening accelerates bone loss as it adds an instability that is enough to prevent any attempt of repair.[11] Hence, when stability is lost, vascular damage is not confined to the supporting cortical bone but is more extensive affecting the opposing cortical bone at the screw exit site, turning the segment into an avascular bone with a rough appearance *(Figure 1)*. Although plate-inherent factors may be decisive in the absence of fracture healing, they are even more so in view of improper im-

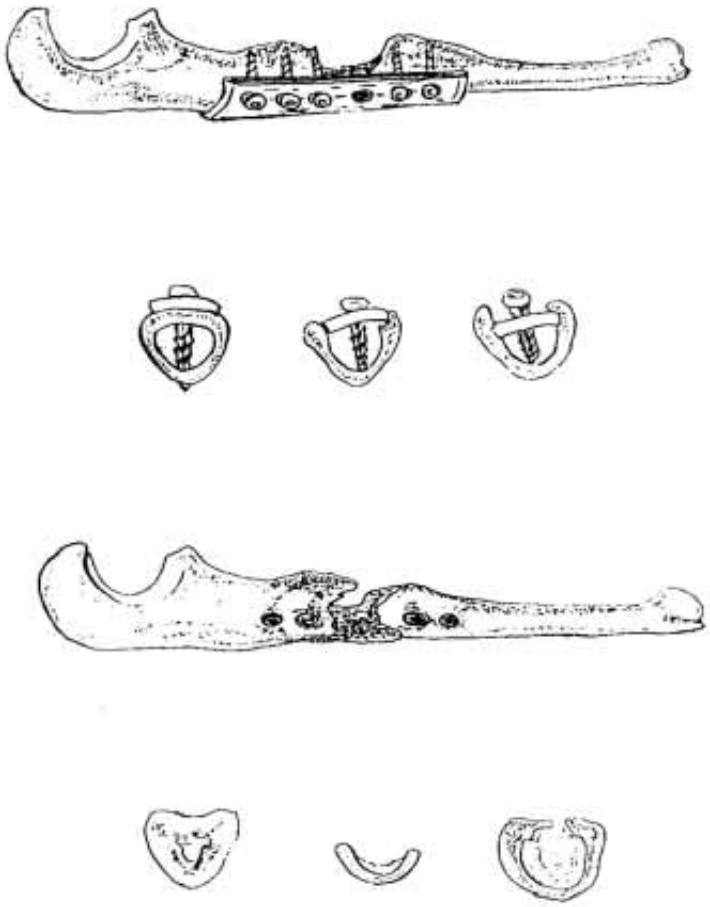


Figure 1. Effect of implant loosening on accelerated bone loss. Plastic deformity causing instability of the fixation plate gradually erodes the shaft. This becomes more obvious when the implant is removed. Damage varies from obliteration of the spinal canal to ring destruction of the shaft (illustrations by the author).

plant selection or a poor surgical technique. An important proportion of our cases was the result of fracture fixation with insufficient plates; the wrong number of cortical bones or plates half the size of the long bone (no longer in use today) leading to significant periosteal detachment; or weak plates (one third the size of the long bone) that do not resist mechanical prompting even if placed on non-weight bearing bones. It is also important to consider that in the presence of added sepsis of the injury, the latter is unlikely to resolve unless the implant is removed. Infection is resolved with Colchero's protocol. The problem lies in the status of residual bone, particularly if cortical loss has occurred, since it makes it difficult to achieve good stability when the Hunec nail is introduced. It is more practical, therefore, to complete the diaphysectomy by removing the damaged bone and replacing it with a graft.

There is little experience in resolving bone loss at the forearm level using the Ilizarov transport system, without overlooking the technical difficulty, complications, and time that the patient has to wear an external device.[12] Hence, it would be simpler to bridge the defect.

The vascularized fibular graft has been broadly accepted. It allows for a more biological fracture healing. For some authors it even provided a better management of infection.[13,14] The mechanical and geometric ratio makes it easier to adapt to the rest of the shaft.[15,16] Other authors suggest that the vascularized iliac crest graft favors earlier union because of its cancellous structure.[17] The different reports about this have reached no consensus as to the type of implant to be used and state that having a vascularized fibula is more important than stability. Unfortunately, microvascular surgery procedures are unaffordable in many hospital settings. Furthermore, they involve a long operative time, even with two surgical teams.[18] The iliac crest graft was found to have an excellent taking capability and, if shortened as a "fragment", it also provides a sufficient geometric adaptation factor. In addition, when placed in non-weight bearing bones, the mechanical factor is sufficient considering the cortical bone accounts for two thirds of its length. The cortical bone is also thin allowing for an early invasion of the periosteal circulation. Thus, the graft serves the triple role of internal fixator, defect-bridging material and osteogenesis promoter.

The Hunec nail is an easy-to-use system providing a compliant type of stability. Compared to plates, it does not interfere with periosteal circulation. This is of great significance from the standpoint of bone healing and graft taking. It also allows for a better radiographic control.[3,19]

Vander handled cases of bone loss due to tumors or femur and tibia infections. He reported no significant difference when

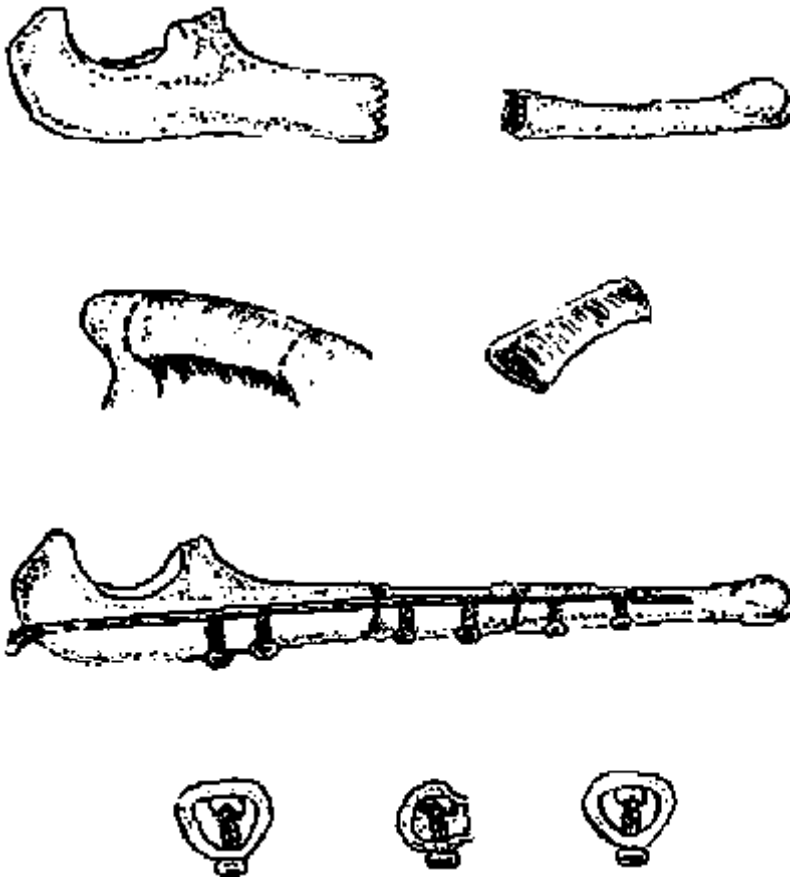


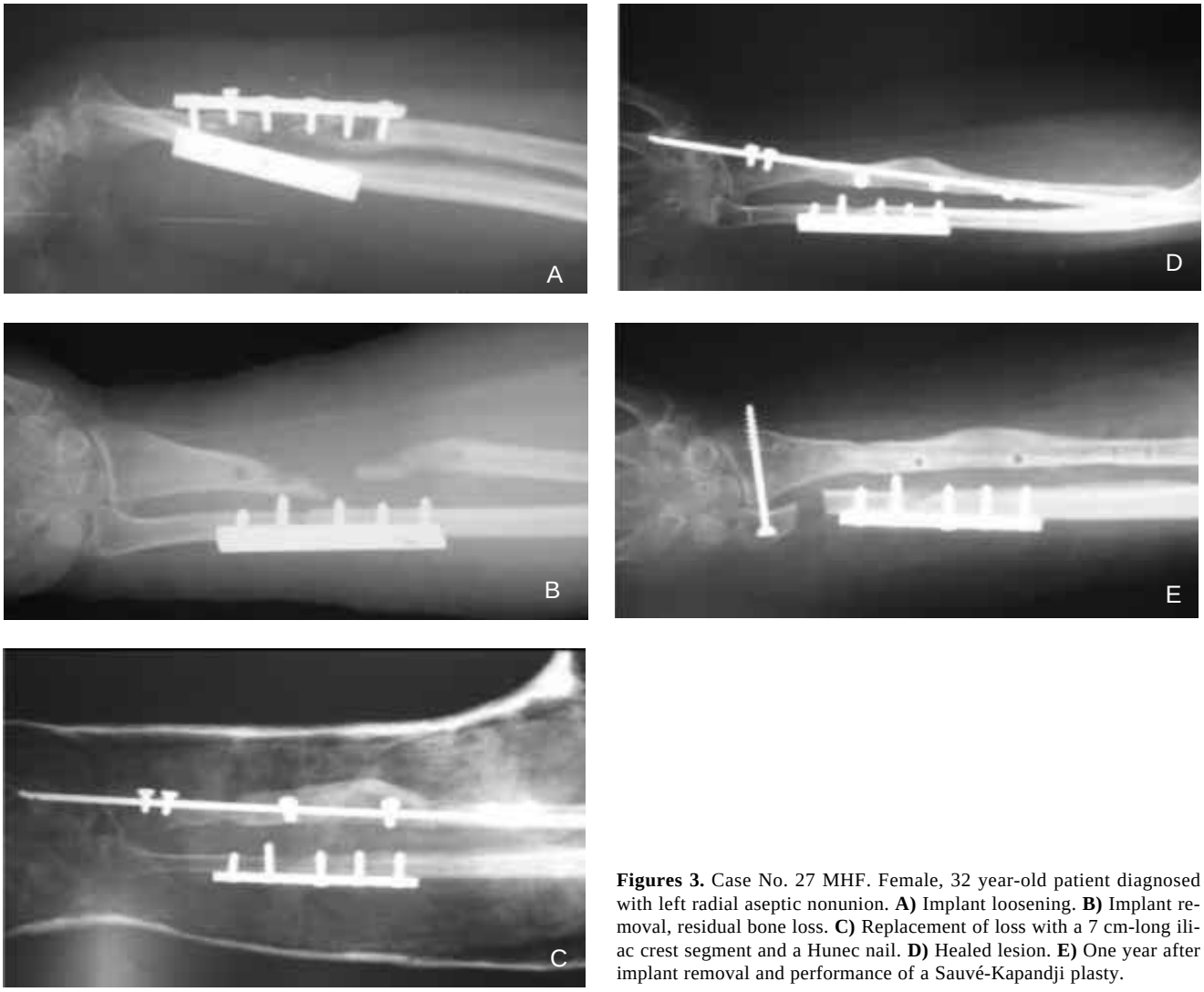
Figure 2. Technique used: diaphysectomy to remove the affected bone. The iliac crest graft is harvested as a "segment"; a marrow canal is prepared; the Hunec nail is inserted with the segment midway between the two nonunion ends and the locking is completed (illustrations by the author).

bank allografts fixated with a plate were used as compared with intramedullary nailing. However, refracture rates were indeed more significant when plates were used.[20] Interestingly, Vander reported that union is more readily achieved when the bone lost was replaced with a segment through which an intramedullary nail passed. This matches the findings by Chung Soo Han, who reported better results with internal rather than external fixation in a study on vascularized grafts.[21]

The length of the iliac crest segments ranged from 3 to 7.5 cm. Salibian[17] reported the possibility of obtaining vascularized iliac crest segments, 6 to 9 cm long. Grace,[8] who used non-vascularized iliac crest, limited the process to segments smaller than 5 cm and Moroni managed defects mostly with segments 2 to 3.5 cm long with non-vascularized fibula or iliac crest graft albeit most were fixated for stability purposes contralateral to the tibial cortical graft.[9] This author reported a healing period of 16.4 weeks for the ulna and 12.5 weeks for the radius, similar to ours. As in other reports, there were more cases of ulnar than radial fractures and the bone-healing period was longer for the ulna. This is probably so due to the repercussion of torsion forces which are different for the ulna and the radius.[9]

Our healing period is similar to that reported for the vascularized fibula even if, as we emphasized, our mean operative time was close to 90 minutes including the graft harvesting, which has many advantages. Moroni points out that wound healing occurs per primam intentionem; this applies to lesions fixated with plates. We identified three graft-taking periods: first, bone density increased until it was similar to that of the ends of nonunions; second, bone callous formation occurred (usually the proximal callus appeared earlier); and finally, a gradual change in trabecular orientation was observed between one and two years after healing *(Figure 2)*.

In terms of complications, four cases were considered as failures. The first one was an ulna; the initial insufficient locking resulted in loosening and migration of the nail at about two months after the surgical procedure. This was resolved by modifying the nail locking without placing the graft again. The second one was a radius requiring a graft chip supply about 20 weeks after the surgery. Both cases healed later within an average period of time similar to the one reported. Two more cases had sepsis reactivation at the radius level with graft loss in patients with lesions in both forearm bones. One was secondary to a gunshot wound and the other to high-energy trauma. Both cases had soft tissue compromise. Sepsis resolved in both patients, but having undergone multiple surgical procedures, they refused a new surgery and the nonunion lesion was left as a defect. One case developed tendonitis of the extensor pollicis longus muscle, which resolved when the implant was removed. Five patients were subject to the Sauve-Kapandji-type plasty *(Figure 3)* due to radioulnar distal instability secondary to previous dislocations. Generally, the ranges of motion were recovered. However, pronation-supination was impaired in



Figures 3. Case No. 27 MHF. Female, 32 year-old patient diagnosed with left radial aseptic nonunion. **A)** Implant loosening. **B)** Implant removal, residual bone loss. **C)** Replacement of loss with a 7 cm-long iliac crest segment and a Hunec nail. **D)** Healed lesion. **E)** One year after implant removal and performance of a Sauvé-Kapandji plasty.

six patients. Three of them had bone loss in both bones. The remaining three patients had undergone more than two prior surgical procedures. In terms of the donor area, pain in all patients was consistent with reports for this kind of graft.[22] It was moderate to intense during the immediate postoperative period, but gradually subsided and eventually no discomfort was reported, except for one patient who developed a paresthetic neuralgia that resolved with physical therapy.

It was found that using an iliac crest segment and a Hunec nail is a safe and effective procedure in cases of forearm bone loss. The procedure is readily performed requiring a relatively short operative time. Undoubtedly, this represents a major advantage over other procedures.

Regardless of the size of the defect, if circulatory conditions and the status of surrounding soft tissues are good, the outcome should be satisfactory. Furthermore our procedure allows for better rehabilitation and a quick return of the patient to a productive environment. Moreover, this is not an expensive procedure, which is yet another advantage to consider.

Bibliography

1. Tauber C, Pritsch M: Non-union of forearm fractures with reference to plate osteosynthesis. *Orthop Rev* 1980; 9: 80-91.
2. Caden JG: Internal fi9xation of the forearm fractures. *J Bone Joint Surg* 1961; 43-A.
3. Colchero F: La etiología de la seudoartrosis. *Gac Med Dist Fed* 1984; 1: 125-129.
4. Boyd HB: The treatment of difficult and inusual non unions. With special reference to the bridgingof defects. *J Bone Joint Surg* 1943; 25: 535-552.
5. Miller RC, Phalen GS: The repair of defects of the radius with fibular bone grafts. *J Bone Joint Surg* 1947; 29: 629-636.
6. Spira E: Bridging of bone defects in the forearm with iliac graft combined with intramedullary nailing. *J Bone Joint Surg* 1954; 36-B: 642-646.
7. Dabezies EJ, et al: Management of segmental defects of the radius and ulna. *Traum* 1971; 11: 778-788.
8. Grace TG, Eversman WWJr: The management of segmental bone loss associated with forearm fractures. *J Bone Joint Surg* 1980; 62(7): 1150-1155.
9. Moroni A, et al: Surgical treatment of isolated forearm non-union with segmental bone loss. *Injury,* 1997; 28(8): 497-504.
10. Chung S, et al: Vascularized bone transfer. *J Bone Joint Surg* 1992; 74-A:1441-1449.

11. Colchero F: Clavos bloqueados en el tratamiento de las fracturas y las seudoartrosis de los huesos largos no sometidos a la marcha. *Gac Med Dist Fed* 1984; 1: 255-258.
12. Esser R: Treatment of a bone defect of the forearm by bone transport. A case report. *Clin Orthop* 1996; (326): 221-224.
13. Jupiter JB, et al: Treatment of segmental defects of the radius with use of the vascularized osteotocutaneous fibular autogenous gaft. *J Bone Joint Surg* 1997; 79(4): 542-549.
14. Dell P, Sheppard J: Vascularized bone grafts in the treatment of infected forearm nonunions. *J Hand Surg* 1984; 9(5): 653-658.
15. Sallés BG, et al: Injerto vascularizado de peroné y minifijador externo en defectos óseos del miembro superior. *Rev Cubana Ortop Traumatol* 2001; 15(1-2): 32-4.
16. Chantelot C, et al: Massive bone loss of the forearm skeleton in trauma victims: six reconstruction's with a free fibular Transfer. J Bone Joint Surg *(British volume)*. London 2004; Vol. 86: 42.
17. Salibian AH, Anzel SH, Salyer WA: Transfer of vascularized grafts of iliac bone to the extremities. *J Bone Joint Surg* 1987; 69(9): 1319-1326.
18. Espinoza A: Trasplante de peroné vascularizado. Reconstrucción de pérdidas óseas segmentarias mayores de 6 cm. *Rev Mex Ortop Traumatol* 1996; 10(5): 214-219.
19. Colchero F: Tratamiento integral del paciente con infecciones óseas. Edit. Trillas, 1990: 104-112.
20. Vander Griend RA: The effect of internal fixation on the healing of large allografts. *J Bone Joint Surg* 1994; 76(5): 657-663.
21. Colchero F, Velázquez J: Clavos bloqueantes. *Rev Med del IMSS* 1985; 21(4): 95-102.
22. Goulet JA, Senunas LE, De Silva GL, Greenfield ML: et al: Autogenous iliac crest bone graft. Complications and functional assessment. *Clin Orthop*. 1997; (339): 76-81.