

This is to state that this thesis work entitled 'Evaluation of synthetic bone graft substitute hydroxyapatite in the management of various orthopaedic conditions' has been carried out by me, under the guidance of Prof. C. M. Badole and Prof. K. R. Patond, in the department of Orthopaedics, M.G.I.M.S., Sevagram, Wardha, Maharashtra.

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Evaluation of synthetic bone graft substitute
hydroxyapatite in the management of
various orthopaedic conditions

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ABSTRACT AND CONCLUSION

A randomized study was conducted to know the efficacy of use of Hydroxyapatite as a bone graft substitute in union of fractures and other bone defects. Of the 37 defects in 33 patients, union was seen in 29 patients. Average follow-up was 7.9 months of the available 29 patients for follow up, ranging from 1.5 to 21 months. The mean defect size was 4.9 cu.cm. Non union and tumor recurrence were seen in 1 patient each. Minor complications such as soft tissue infiltration of hydroxyapatite, superficial infection and wound gaping causing nodule formation and pain were noted in few patients. Superficial infection responded adequately to regular dressings and proper antibiotics and pain following the nodule formation gradually subsided over a period of 5-6 months.

This study concludes that hydroxyapatite can be a useful bone graft substitute with avoidance of donor site morbidity. Complications arising by use of hydroxyapatite per se, are readily manageable.

SCOPE OF THE STUDY

With the exception of blood, bone is the most frequently transplanted tissue in humans. Virtually every operative day, orthopaedic surgeons, neurosurgeons, craniofacial surgeons and periodontists need to fill defects in the bone or augment deficient bone. Bone harvested from donor sites is the gold standard for grafting procedure. Although autograft is the standard that all bone graft substitutes must meet or exceed, autograft has significant limitations, including donor site morbidity, inadequate amount or inappropriate quality (osteoporotic). Thus, there is an obvious need for a bone graft substitute to serve as an off the shelf alternative to autograft.

Internal use of synthetic materials to fill in bony defects was reported in 1892 by Dressmann who used a slurry of Plaster of Paris and 5% phenol. Chiroff first recognized that corals made by marine invertebrates have a structure similar to both cortical and cancellous bone and that they might be suitable for skeletal substitution. A simple hydrothermal exchange process converts delicate coral carbonates into mechanically superior hydroxyapatite without altering the internal structure [Cornell, 1999].

Holmes et al, 1984 reported of 18 metaphyseal and diaphyseal fractures managed with hydroxyapatite bone grafts. At 15 months follow-up, all fractures appeared healed. Bucholz et al, 1987 implanted hydroxyapatite for traumatic long bone defects in 46 patients (34 metaphyseal and 12 diaphyseal).

Passuti et al, 1989 have advocated the use of ceramics as extendors for autogenous bone graft for long segment fusions in corrective deformity surgeries.

Uchida et al, 1990 reported 60 benign tumours treated by resection and curettage followed by implantation of calcium hydroxyapatite ceramic. After follow-up of six to sixty months (average 36), no patient had local recurrence of the tumour or any adverse effect from the implant. Gouin et al, 1995 followed up 19 of 21 patients of bone defects following tumors, non-unions and osteotomies, treated with synthetic hydroxyapatite.

Similarly, Itokazu et al, 1996, Elsinger and Leal, 1996, Kopylov et al, 1996, Hardy et al, 1997, Oonishi et al, 1997, Thalgott et al, 1999, and Yamamoto et al, 2000, have successfully

used hydroxyapatite in various fracture defects, filling of bone voids in tumours and in other conditions such as spinal fusions, osteomyelitis and arthrodeses.

MATERIALS AND METHOD

The aim of the study was to determine the efficacy of hydroxyapatite bone graft substitute in various orthopaedic conditions, and to assess the duration of union with use of hydroxyapatite as bone graft substitute.

Design of Study:

The study was a prospective clinical trial. The independent variable of interest was the graft material - Hydroxyapatite. The dependent variables were union of fractures, functional outcome (as measured on the basis of pain with activities of daily living and impairment in it) and rate of complications.

Criteria for exclusion:

- Osteomyelitis of the involved limb.
- Concurrent use of corticosteroids or immunosuppressive agents.
- Pathological fractures.
- Pre-existing vascular disease.
- Co-existing degenerative / metabolic bone disease.
- Expectation of non-compliance because of mental illness or alcoholism.
- Fractures or bone defects requiring more than 30 cc graft material.
- Open fracture with type III B / III C wounds.

Patients admitted in the department of Orthopaedics and Traumatology of MGIMS, Sevagram, Wardha, Maharashtra, India, from August 2000 to April 2002 with fractures of long bones, spinal deformity or skeletal deformities requiring surgical correction were subjected to surgery where bone graft substitute in the form of hydroxyapatite was inserted (random selection). The decision to use Hydroxyapatite over autogenous bone graft totally rested upon the operating surgeon.

Hydroxyapatite was made available in a sterile packet of 10 cc granules / blocks / dowels.

In the routine operation theatre, under suitable anaesthesia, with or without radiological control the necessary procedure was performed. The size of bone defect was then assessed. The site was then washed with Normal saline and dried completely of blood. Any active

bleeding in the vicinity of the grafting site was controlled. The sterile hydroxyapatite implant was taken in a dry bowl. After assuring that the site was completely dry, hydroxyapatite was inserted into the bone defect. Care was exercised while inserting this hydroxyapatite implant that it did not spill into the soft tissues. This was made easier when a bone gouge was used for inserting the hydroxyapatite implant. Before closure it was checked that the defect was filled completely with hydroxyapatite. Wound closure was done with soft tissue coverage over the grafted site. Negative suction drain, if needed, was then placed over this layer. This was done so as to prevent the hydroxyapatite granules from coming out through the negative suction drain. Splint was then applied as needed.

Wound examination was done primarily on the third or fourth post operative day and subsequently on the 10th – 12th post operative day when the sutures were removed and the patient discharged if the wound was healthy. In cases where wound was not healthy, wound swabs were taken and sent for culture, broad spectrum antibiotics were continued till the reports were available and then the antibiotics were changed accordingly, if needed. Regular dressings were done till the wound healed completely and then the patient was discharged.

Follow-up:

Follow-up of the patients was done at 6 weeks, 3 months, 9 months, 12 months and at the end of study. At each follow-up the patients were evaluated clinically and radiologically. Clinical assessment of wound and assessment of the activities of daily living were done.

Radiographs were taken to assess -

- the fracture union or filling of bone defect.
- any complications such as loss of fixation, delayed union, non-union or implant failure.

OBSERVATIONS AND RESULTS

Patient characteristics:

33 patients were included in the study of which 27 were males & 6 were females. Age of patients ranged from 5-85 years; mean being 39.69 years. Of the patients studied, three patients had previous surgeries with implant failure. There were three patients of non-union and two patients of delayed / mal -union who were previously treated conservatively.

Fracture/Defect characteristics:

Of the 37 defects implanted with hydroxyapatite, 17 [45.9 %] were in femur, 2[5.4%] in tibia, 6[16.2%] in humerus, 7[18.9%] in radius, 3[8.1%] in ulna and 2[5.4%] in spine. Diaphyseal bone defect was in 22 fractures/lesion [59.4%], metaphyseal in 13 fractures/lesions [35.1%] and in one patient both diaphyseal and metaphyseal defect were implanted with hydroxyapatite in the same sitting.

Distribution by type:

In our study 22 fractures [59 %] of 37 defects were comminuted, old were 4[10.8 %], non-union was in 6 fractures [16.2 %]. There were two patients [5.4 %] each of spine and implant failure.

Operative characteristics:

In 33 patients 34 surgical procedures were performed and 37 defects were implanted with hydroxyapatite. 18[52.9%] under general anaesthesia.

Duration of surgery:

Average duration of surgery was 99 minutes, ranging from 60 to 180 minutes. Rigid fixation was achieved in most i.e. 28 [75.6 %] fractures.

Defect:

Average size of defect filled with hydroxyapatite was 4.9 cu.cm.; ranging from 0.75 cu.cm. to 12 cu.cm.

Clinical assessment:

- Wound healing:

In most patients, wound healing was normal. Sterile effusions were seen in two patients and partial wound gaping following superficial infection in one patient.

- Range of movements:

On fracture healing the range of movements was almost normal in most patients after adequate physiotherapy. No significant restriction of movements was noted, and most patients were able to return to work or could perform activities of daily living.

Complications:

Soft tissue infiltration of hydroxyapatite implant was seen in three cases of the study. This resulted in pain & nodule formation in the subcutaneous portions of the forearms of two patients. Pain gradually subsided by the end of 6 months. Superficial infection and wound gaping was noted in 1 patient. Non union was seen in 1[4.2%] patient, and recurrence of tumor occurred in one.

ANALYSIS & DISCUSSION

Of the 37 defects in 33 patients in the study, 31 [83.7%] were followed up at least till their expected time of union. Of these 29 [93.5%] were found clinically and radiologically united. Two patients lost to follow-up-one male [subtrochanteric fracture] and one female intertrochanteric fracture]. Two patients were operated upon recently and hence even their minimum follow up was not possible. Average follow-up was 7.9 months of the available 29 patients for follow up, ranging from 1.5 to 21 months.

Humerus:

Of the 6 humeral fractures 4 were followed up at least till their expected time of union [follow up range - 5 months - 1 year]. All 4 united at an average duration of 5 months. Two patients with fracture humerus reported for follow up till 3 months post operatively. Till this period both patients had no complications and were progressing towards union.

Forearm bones:

Of the 10 forearm bone fractures in 7 patients, 7 were in radius and 3 in ulna. All 10 [100 %] fractures united at an average of 3.9 months follow up [follow up ranging from 4 months - 21 months].

Femur:

Of the 17 femoral fractures (in 16 patients), 13 were followed up till or more than the usual time required for their union. Union was seen in all these 13 fractures at an average of 5.9 months [100% union].Two femoral fractures were operated recently (then) and hence their follow up wasn't possible. Two patients, one each of subtrochanteric and intertrochanteric fracture were lost to follow up.

Tibia:

Two patients with tibial defects were implanted with hydroxyapatite. One patient with non union of tibial diaphysis was treated by open reduction and internal fixation with 8 holed Dynamic compression plate and screws. Patient was lost to follow up till one year post operatively. At one year post operatively, he presented with implant failure and infection.

A child with polyostotic fibrous dysplasia was implanted with hydroxyapatite in tibial lesion after curettage. Recurrence was seen after three years.

Spine:

A patient of Pott's spine [L5 - S1] was operated upon by an anterior approach for curettage and fusion. Defect was then filled with hydroxyapatite [intraoperative decision]. Patient improved clinically but radiological fusion was not seen at 6 months follow up. Incorporation of hydroxyapatite implant was present. In a patient of spondylolisthesis with Intervertebral disc prolapse with neurodeficit, fusion was not evident at 3 month of follow up.

DISCUSSION

Autogenous graft has three overlapping clinical roles: it can provide immediate structural support, it can provide an osteoconductive scaffold for the filling of a defect and it can provide an osteogenic stimulus from both cells & growth factors. But the demand of autografts fairly exceeds the supply. Another major drawback is that postoperatively the patients very often suffer pain at donor site. With autograft harvesting procedure the operation time is prolonged considerably with increased costs and risks for the patient.

The synthetic Hydroxyapatite implant is osteoconductive. As it is brittle with little strength, its use is recommended with rigid internal fixation using implants such as plates and screws so as to prevent the hydroxyapatite implant from loading.

Histologically, it has been shown that the osteons contained within the Hydroxyapatite pores after bony investment are not initially arranged along load - bearing forces, [Sandhu and Boden, 1998]. In the present study good incorporation of hydroxyapatite was seen in all the fractures that united or were uniting. Bone ingrowth was seen radiologically as traversing of trabeculae across the fracture or lesion site at last follow up in ??? patients.

The average duration of surgery was 99 minutes. This would have definitely been more had autogenous bone grafting been done as a separate surgical procedure.

Duration of anaesthesia required was also reduced as the need for second surgery for harvesting a graft was eliminated. This prevented intra-operative and postoperative complications due to prolonged anaesthesia especially in old patients which were in a significant number [9 patients were > 50 years] in our study.

Spinal fusion is difficult to visualize early [Thalgott et al,1999]. But symptomatic improvement in these patients and incorporation of hydroxyapatite without its displacement would suggest that fusion would result at later follow up.

In the present study, in 4 out of 33 cases , two that lost to follow up and the two in whom even a minimum follow up wasn't possible due to their recent surgery, no wound complications such as effusion or wound infection were seen.

In the case of infective non-union of tibia the patient didn't appear for regular follow up. Also, the patient was non-compliant. In such circumstances complications can be expected and the role of hydroxyapatite implant in its causation is difficult to ascertain. Also, infection and non union per se, are major problems in Tibial diaphysial fractures fixed with Dynamic compression plate and screws .This finding of non union is comparable to studies of Johnson et al, 1996 and Petit and Segal, 1997.

There is potentially an unlimited supply of this implant. In case of Fibrous dysplasia in 5 year child, the availability of adequate amount of autogenous donor bone for grafting is limited. Recurrence was seen after three years follow-up which is comparable with studies of Uchida et al, 1990 and of Gouin et al, 1995.

The dense radiographic image of Hydroxyapatite presented difficulty on quantification of bone ingrowth due to radio-opaque nature of hydroxyapatite and fixation device itself. In most cases of fractures, the adjacent trabeculae blended into the sides of implant without evidences of radiolucent lines at interface.

In a case of benign bone tumour curettage incorporation of hydroxyapatite and union was judged according to the criteria given by Uchida et al, 1990 viz -change in radiolucent line or halo around hydroxyapatite implant, increase in density of radiographic image ,and lack of displacement or dislocation of hydroxyapatite implant.

Soft tissue infiltration of hydroxyapatite implant was seen in the initial three cases of the study. This resulted in pain & nodule formation in the subcutaneous portions of the forearms of two patients. Pain gradually subsided by the end of 6 months. Similar observation was seen in the study by Yamamoto et al, 2000.

Other known complications associated with use of Hydroxyapatite, fracture of hydroxyapatite implant itself and erythema around operation site, were not seen in any case.

Biodegradability of hydroxyapatite is slow [Khan et al, 2000] and according to previous studies it has been seen to persist on radiographs for about 10 years. Conforming to this no evidence of biodegradation was seen in any of our cases studied.

CONCLUSION

From the present study we conclude that use of Hydroxyapatite implant eliminates autogenous bone graft donor site morbidity, and effectively provides a scaffold for bone ingrowth and shows good incorporation within bony defects.

There are very few complications that occur, which can be easily managed. This use of hydroxyapatite implant is safe and effective procedure to autogenous bone grafting.

The use of synthetic bone graft substitutes is increasing rapidly, and it is hoped that transplantation of bone from donors will one day become obsolete. Careful evaluation of various innovative materials is necessary to determine if they are safe and have the desired healing and mechanical characteristics. But the future holds good promise for the directed regeneration of bone, damaged by trauma, disease or degeneration.

MASTER CHART

S.n.	Name	Age	Sex	MRD	DOA	DOS	DOD	Trau / Les	Dur	Site	M/D/b	Infec	Comm	B.Densi	Diagnosis
1	Sanjay	26	M	52797	8/1/00	8/3/00	8/17/00	RTA	1 day	R.thigh	D	-	+	N	Comm # R ShaftFemur
2	Praful Ramesh Ingole	33	M	35397	8/24/00	8/26/00	9/10/00	RTA	7 mo	R.arm	D	-	-	N	NonUnion R Humerus
3	Poonamchand Suryavanshi	30	M	35469	8/25/00	8/26/00	9/7/00	RTA	45 dys	R.f-arm	2D	-	+	N	NonUnion BB R f-arm
4	Bhaskar Manik Karade	46	M	35595	8/26/00	8/26/00	9/7/00	RTA	1 day	L.f-arm	D	-	+	N	Comm # L Radius
5	Sharad Namdeo Purohit	38	M	37458	9/18/00	9/20/00	10/2/00	RTA	6 dys	L.f-arm	D	-	+	N	Comm # L Radius with re-#
6	Chotumiyam Sheikh	40	M	40094	10/20/00	10/25/00	11/8/00	Fall	6 mo	R. arm	M	-	-	N	NonUnion L Humerus
7	Shilpa Diwakar Urkade	20	F	40106	10/23/00	10/25/00	11/8/00	RTA	3 dys	L.arm	D	-	+	N	Comm # D/3rd L Humerus
8	Nikhil Suresh Waghmare	6	M	41409	11/14/00	11/15/00	11/29/00	Deformity	18 mo	L.leg	D	-	NA	o-lytic	Polyostotic Fibrous dysplasia
9	Gunwant Bapurao Shete	28	M	41818	11/20/00	11/22/00	12/4/00	FALL	8 dys	R.thigh	D	-	-	N	# shaft R Femur withimplant failure
10	Kishore Chirkut Masram	30	M	43225	12/11/00	12/23/00	1/5/01	RTA	6 hrs	L.thigh	D	-	+	N	Comm # D/3rd L Femur
11	Ashok Petakar	30	M	43521	12/15/00	01/01/01& 17/01/01	2/4/01	RTA	2 hrs	B/l thighs	2D	-	+	N	Compd. Comm #R shaft Femur, # neck with Comm # shaft L Femur with post dislocation left hip
12	Chagan Vasant Shivankar	20	M	45708	1/18/01	20/01/01	2/6/01	RTA	1 Day	L.f.arm&elbow	Both	-	+	N	Comm.#B.B.Lt f.arm with comm.#olecranon
13	Shrikant Raghunath Khare	50	M	46032	1/23/01	1/29/01	2/9/01	FALL	5 wks	R.shoulder	M	-	+	N	Old Comm # surg Neck R Humerus withepilepsy
14	Kavita Gunvant Zamare	18	F	49043	3/3/01	3/5/01	3/8/01	FALL	1 mth	R.f-arm	2D	-	-	N	Old # BB R f-arm
15	Sahebrao Gokhare	45	M	49517	3/8/01	3/12/01	3/23/01	FALL	1 day	R.f-arm	D	-	+	N	Comm Galeazzi #R f-arm
16	Keshavrao Shiram Banait	58	M	51017	3/31/01	4/8/01	4/30/01	RTA	2 hrs.	R.thigh	M	-	+	N	Comm # ShaftR femur, bicondylar #R femur, # prox R Tibia
17	Mayabai Bapurao Shekar	70	F	52629	4/24/01	4/25/01	5/10/01	Fall	1 day	L. hip	M	-	+	Op	Comm S.T. # L.femur
18	Omkar	30	M	53014	5/12/01	5/16/01	6/2/01	RTA	1mo	L leg	D	-	-	N	Non-union Rt tibia
19	Naresh Ingole	32	M	53936	5/13/01	5/24/01	6/20/01	RTA	8 hrs	R thigh&leg	D	-	+	N	# Neck R Femur,# shaft R Femur ,Comm# P/2 R Tibia
20	Hemant Gaydhane	28	M	54430	5/21/01	6/2/01	6/18/01	RTA	5 hrs	L. thigh & R. leg	D	+	+	N	Compd.,Comm,ST# L.femur.# BB,R.leg,B/l foot drop AS,AR
21	Sharad Balabhau Nirgerkar	52	M	55281	6/1/01	7/7/01	8/2/01	Pain	6 mo	Back	M	+	NA	Op	Pott's spine, L5-S1
22	Seema Shrepat Gautam	45	F	57929	7/8/01	7/16/01	8/3/01	Fall	3 wks	R. arm	D	-	+	Op	Old # shaft Humerus with Implant failure,Rh. Arth.,MR in CCF
23	Mahadev Lahanu Karluke	52	M	58523	7/16/01	7/18/01	7/31/01	Fall	10 dys	L. shoulder	M	-	+	N	Comm # disloc,L Surg neck Humerus
24	Hiraman Taksande	60	M	63305	9/10/01	9/12/01	9/24/01	Fall	6 mo	L. hip	M	-	+	Op	Non Union IT # femur
25	Naresh G. Londhe	30	M	68244	11/16/01	11/17/01	11/30/01	Fall	8 hrs	L. forearm	D	-	+	N	Comm # BB L.f-arm
26	Sudhir Nemate	30	M	69612	12/7/01	12/14/01	12/27/01	RTA	1 day	R. thigh	D	-	+	N	Compd. Comm # shaft, R.femur M/3rd
27	Manish Chaturvedi	30	M	70569	12/20/01	12/23/01	1/17/02	LBA	8 dys	Back	M	-	NA	N	IVDP L4-L5 withSpondylolisthesis with deficit with HT
28	Sukhadevi Bajaj	85	F	70700	12/22/01	12/26/01	1/10/02	Fall	1 day	R. thigh	M	-	+	Op	Disp. S.C. # with intercondyler ext.-femur
29	Champat Nathugi Chamcher	26	M	74007	2/6/02	2/7/02	2/18/02	RTA	3 mo	R. thigh & knee	D	-	+	Op	Comm S.C. with I.C. # R.femur with Implant failure&delayed union
30	Sonabai Ratnam Shirbharye	65	F	74668	2/14/02	2/20/02	3/3/02	Fall	4 dys	R. thigh	M	-	+	Op	Comm S.C. # R.femur with H.T.
31	Arun Sudamrao Deshmukh	52	M	77094	3/18/02	3/30/02	20/04/02	RTA	4 hrs	L.hip,thighknee & leg & D/f-arm R.thigh,	M	-	+	N	Compd. S.C. with I.C. # R.femur, Comm IT and shaft # L.femur,Comm# D/End BB L forearm,Comm# prox.Tibial Metaphysis
32	Namdeo Ramchandra Fale	60	M	79890	4/22/02	4/27/02	5/14/02	Fall	3 days	Rt Thigh	M	-	+	Op	Comm ST # Rt femur
33	Sudamchandra Hassaya	53	M	80193	4/25/02	4/29/02	5/15/02	Fall	25 days	Rt Thigh	M	-	+	Op	Old Comm S.C # Rt Femur

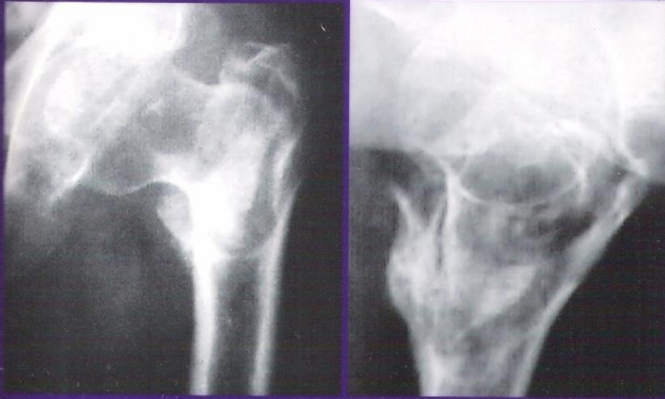
Procedure	Anaesth.	Duration	Rig/non-rig	Defect size	Inf/Eff	Union	Last FU	Complications
ORIF with K nail	SA	90	R	9	-	5mo	11 mo	
ORIF with 6 hole DCP	GA	90	R	8	-	ug	3mo	
ORIF with sq. nails	GA	75	R	1.5[0.5&1]	-	4mo	8 mo	Soft ts. infiltration ,backing out of implant
ORIF with sq. nail	GA	90	R	0.75	-	4mo	21mo	Soft ts. infiltration
ORIF with sq. nail	GA	75	R	0.75	-	4mo	18 mo	
ORIF with 6 hole DCP	GA	90	R	4	-	ug	3 mo	
ORIF with 6 hole DCP	GA	120	R	3	-	5mo	5mo	
Curettage & Hydroxyapatite grafting	GA	60	Nil	12	-	6mo	1 yr	
ORIF with K nail	SA	90	R	6	-	6mo	6mo	
ORIF with K nail	SA	75	R	9	-	6mo	1 yr	
ORIF with 10 hole JNP& IF screws-L, ORIF with K nail-R	GA&GA	150 & 90	NR&R	12 [6&6]	-	6&6m	16 mo	Re# & implant Failure
ORIF Ulna with 6 hole DCP,ORIF Radius with sq. nail,TBW Olecrano	GA	120	R	1.0 & 0.5	-	4&3m	16mo	
ORIF with Rush nail	GA	75	R	1.5	-	5mo	1 yr	
ORIF with sq.nails	RA	60	R	0.5&0.25	Eff	4mo	14mo	
ORIF with 6 hole DCP	GA	60	R	0.5	-	4mo	4 mo	
ORIF with L plate& IF screws	SA	150	NR	6	Eff	6.5mo	9 mo	
ORIF with Richard's DHS & 7 hole plate	SA	90	R	8	-	lost	0	
ORIF with DCP	SA	105	R	7.5	-	NU	1 yr	Non-union with infection
ORIF with 14 hole DCP&Moore's pins	SA	180	R	7.5	-	6mo	12mo	
ORIF with Richard's DHS & 7 hole plate	GA	90	NR	3	-	lost	0	
Anterior fusion	GA	90	Nil	8	-	ug	7mo	
Implant Removal &ORIF with V nail	RA	75	R	6	-	6mo	6 mo	
ORIF with Rush nail & K wires	GA	90	NR	3	-	4mo	4mo	soft ts. infiltration
ORIF with Richard's DHS & plate	SA	120	R	8	-	6mo	9mo	
ORIF of Radius with closed IM ulnar nailing	GA	60	R	1	-	4mo	4mo	
ORIF with K nail	SA	150	R	4	-	ug	3 mo	
Laminectomy with discectomy L4-L5	GA	120	Nil	1	Inf	ug	3 mo	Wound gaping
ORIF with 9 hole condylar blade & plate	SA	105	R	12	-	ug	6 wks	
Realignment of condylar blade & plate	SA	60	NR	6	-	ug	2 mo	
ORIF with 10 hole condylar blade & plate	SA	105	R	4	-	ug	2mo	
ORIF with 10 hole condylar blade & plate with Richard's DHS & plate with 6 hole broad DCP with CRIF with K wires	GA	180	NR	12	-	ug	2mo	
ORIF with DHS & 7 hole plate	SA	120	R	3.375	-	-	nil	
ORIF with DCS & Plate	SA	90	R	12	-	-	nil	

Abbreviations used

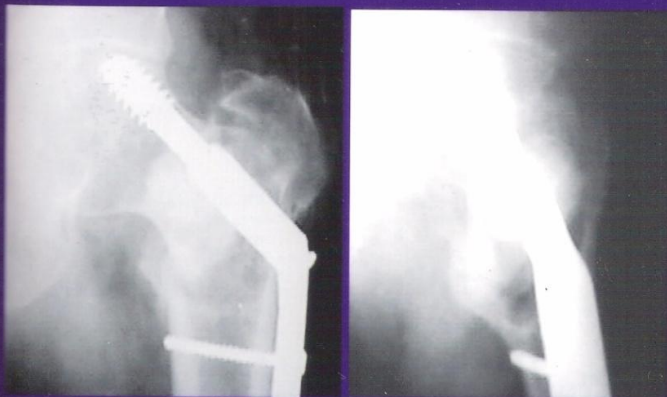
DOA = Date of admission
DOS = Date of surgery
DOD = Date of discharge
M = Metaphysis
D = Diaphysis
Comm = Comminuted
Compd = Compound
Inf. = Infection
Eff. = Effusion
FU = Follow up
ts. = Tissue
Op = osteoporotic
N = Normal

ILLUSTRATIONS

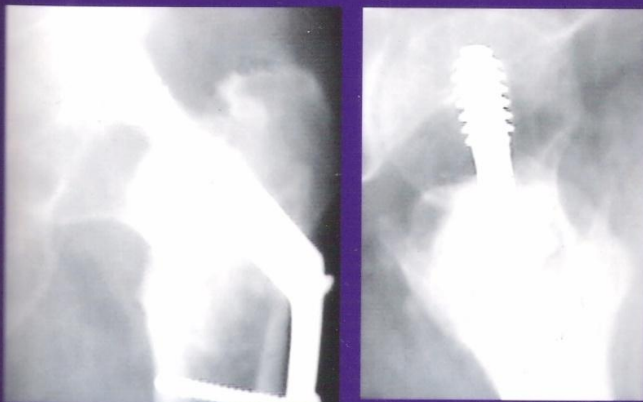
**Fig.1 -
Non union Intertrochanteric
fracture**



Pre op



Immediate
post op



9 months
post op

**Fig.2 -
Comminuted #
Radius**



Pre op



Immediate
post op



21 months
post op

Fig.3 - 1 Month old # Both bones forearm



Pre op



Immediate
post op



8 months
post op

Fig.4 - Comminuted # shaft distal Femur



Pre op



Immediate
post op



9 months
post op

Fig.5 - Polyostotic Fibrous Dysplasia



Pre op



Immediate
post op



12 months
post op

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