DISCUSSION
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This study was conducted in the Department of Orthopaedics, M.L.B. Medical College on 18 cases of fracture of both bones of forearm, which were randomly selected and treated by two different modalities of internal fixation i.e. the intramedullary square nail and the Dynamic compression plate (DCP). Two groups were formed, Group I treated by square nail fixation and Group II treated by D.C.P. fixation. Patients were studied from the day of admission through the pre, intra and post op period, to the complete follow up till the patient achieved maximum possible functions of the injured limb. The data collected in this manner for the two group of cases was evaluated, analysed and compared with each other and with the previously done studies reported by various authors at different centres in the world.

The variable factors associated with patients in the two groups such as age, sex, mode of injury, site & type of fracture and nature of injury were compared so that results of operation could be evaluated and compared properly.

While evaluating age distribution in this series of patient, the overall age of patients came out to be 36.5 years. Average age of Group I was 35.8 years and that of Group II was quite similar i.e. 38.4 years. Overall more than 60% patients belonged to age group of 20-40 years, the young active adult age group, which is most prone to incidents of trauma.
The average age in our study was about 10 years less than that reported by different western authors. *Marek 1961* reported an average age of 43 years and *Burnwell and Charnley 1964* reported average age of 44.8 years in their series of cases. This discrepancy probably occurred due to the fact that the average life expectancy in our country is quite less than that of western world.

These same socio-cultural differences explain the lower percentage of females amongst injured cases. 34% and 30% female patients were reported by Marek (1961) and Burnwell (1964) in their series of cases. Whereas the percentage of female patients in our series in Group I was 15.4% and Group II was 20%.

Considering the *mode of injury* in our series of cases, out of total of 18 cases, road traffic accidents alone accounted for 8, 44.4%, cases direct hit by stick or lathi 4, 22.2%, fall from height 22.2%, industrial accidents 1% and 1% due to other causes. This distribution was somewhat similar to the series of cases reported by Shah et al (1988) in which R.T.A. accounted for 5.3% cases, industrial injuries 14.7%, domestic injuries 16% and other causes 13.9%, which included fall from height or direct hit by stick.

Regarding the *occupation* of cases in our study, most of them, 33%, were daily wage laboureuses or poor farmers. The dominant upper limb was affected in 42.3% cases in Chapman series. But in our study, both side of limb appeared with equal frequency i.e. 50% each. In Group I, most of the cases, 69.2%,
had fractures through middle 3rd. In Group II, all 100% cases had fracture through middle 3rd of forearm.

In a study by Chapman et al, in a similar manner the middle 3rd of forearm was found to be most vulnerable portion of forearm to be fractured in any incidence of trauma.

While observing the *pattern of fracture* in our series of cases, it was found that in Group I maximum, 53.9%, of fractures were comminuted, 7.7% segmental and rest oblique. Whereas there was no case with oblique, spiral, or segmental fracture pattern in Group II. Here, in Group II, 90% of fractures were transverse and rest 10% were comminuted. In the study by Chapman, the proportion of various pattern of fracture was quite similar to our Group I patients except that comminuted fracture pattern was found in 53% of cases. This discrepancy could be explained by the poor quality of preoperative radiographs where small portion of comminution along fracture line could not be seen.

While evaluating the *nature of injury* in our series of cases it was found there were 76.9% cases with simple and 23% with compound injuries in Group I. This was quite similar to Group II where 80% cases had simple injury and 20% cases had compound injury. Out of total of 4(22%) cases of compound injury in our study, 2(11%) were Grade I with puncture wound and 2(11%) cases with Grade II and Grade III compound injuries respectively. This distribution pattern was quite similar to Anderson series where 88.6% fracture were simple
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in nature. 40% cases had associated multiple injuries in Chapman's series of cases, while in our study this number was marginally less, with 27.8% cases having associated injuries.

The average time interval between injury and operation in Anderson's series was 10.6 days. In Chapman series 68.5% cases were operated with in two weeks after injury. In our series of cases, also, 53.8% cases of Group I, 80% cases of Group II, and overall 61.1% cases got operated with in two weeks after the date of injury,

Knight & Purvis 1949, Holdsworth 1949 and Smith 1956 stated that fractures of both bones of forearm are unsuitable for conservative treatment. Adler 1965, Chapman and Frankel 1973 and Sisk 1980 concluded that angulatory and rotatary, malunion and non-union occurring in these fractures treated by closed reduction and external immobilization resulted in marked functional impairment. Thus we set out in our study to compare the two modes of internal fixation.

Sisk 1980 studied the principles of intramedullary fixation, where he found intramedullary fixation better when the fractures occurred through the narrow part of the medullary canal. Smith and Sage 1957, Sage (1959) Marek (1961) Cotler and associates (1971) in their studies concluded the favourable results of intramedullary nail fixation.


In this present series of patients we have set out to evaluate various aspects of these two modalities, square nail and DCP plate, and to compare their results. For this, out of a total of 18 cases of forearm fractures, 13 were selected randomly and treated by O.R.I.F. with Talwalkar's square nail. Other 5 cases were treated by O.R.I.F. with small fragments DCP plates and 3.5mm cortical screws.

The overall average operative time noted in this series was 1 hrs 47min. Average operative time for Group I was 1hrs 40min and for Group II 1hrs 55min.

The use of bone grafts has been reported by many authors. Jinkins (1960) and Caden (1961) in their series of patients had reported use of bone grafts at the time of internal fixation in 30.3% and 11.5% cases respectively. Anderson et al (1975) used bone grafts in 25.9% of patients for fractures in which more than one third of the circumference of the shaft was comminuted.

In our series of cases, autogenous iliac cancellous bone grafts were used in 27.7% of patients at the time of internal fixation using the Anderson et al (1975) criteria, i.e. when the comminution involved more than one third of the circumference of the shaft of radius or ulna.
As regarding the *duration of post operative immobilization* Anderson et al (1975) in his series, used A/E POP cast for post operative immobilization in most of his cases. The average duration of POP cast immobilization in his series of cases was 7.6 weeks. He had suggested in his study that if there was minimum comminution of one or both bones, good anatomical alignment and fixation had been achieved, and the patient was intelligent and co-operative, no external immobilization was necessary, but no strenuous activity was allowed till fracture had consolidated. But in cases with comminution, less than perfect reduction and internal fixation and poor cooperation of patient, he suggested that an A/E POP cast must be applied for six to eight weeks.

Similar criteria were applied in our study, and all patients were given A/E POP slab immobilization till the sutures were removed which was replaced by A/E POP cast thereafter. The minimum duration of post operative immobilization was 6 weeks in Group I and 3 weeks in Group II. The maximum duration in Group I was 20 weeks and Group II was 12 weeks. The average duration of post operative immobilization in cases fixed with square nail (Group I) came out to be 12 weeks and 3 days, and in Group II (fixed with D.C.P.) it came out to be 7 weeks and 2 days. This was because anatomical alignment, compression at fracture site, and rigidity of fixation was better with D.C.P. in Group II.

*As regarding immediate post operative complications* Marek
(1961) reported one patient of fracture of upper 3rd of radius with transient motor paralysis of posterior interosseous nerve. Anderson (1975) reported five posterior interosseous nerve palsy cases when D.C.P. fixation was done in fracture through proximal part of radius. Four cases recovered in six weeks and one required full six months for recovery.

Similarly, in our study there was one, 7.7%, case of posterior interosseous nerve neuropraxia injury in Group I, and one, 20%, in Group II. The Group I patient had proximal 3rd fracture of radius and the paralysis recovered in 9 weeks, and Group II patient recovered in 3 we eks. Moreover, we encountered 1, 7.7%, case of tourniquet palsy in Group I which recovered completely in 12 weeks.

As regarding the *early complications*, which presented with in one week post operatively, in Group I there were 2 cases, 15.4%, of superficial infection which healed in 3 weeks. In Group II there was one case of superficial infection, a case with Grade I compound injury initially, which healed in 3 weeks.

This incidence was comparable to studies by Sage (1959) who reported 2 cases of superficial infection which responded to antibiotics and antisepctic dressings. Anderson (1975) also encountered few cases of superficial infection which healed with in 2 weeks.

As regarding the *late complications*, Anderson (1975) reported
(1983) encountered 5.4%, Burwell and Charnley (1964) 5.3%, Cady and Dodge (1972) 5.1% deep infections.

In our study in Group I, there was one case of deep infection, which led to acute osteomyelitis of both bones of forearm. This patient had Grade III compound injury initially. The incidence in Group I was therefore 7.7%. But there was no case of deep infection in Group II patients.

In Group I, there was one case, 7.7% of olecrenon bursitis due to protruding proximal end of ulnar square nail. After the fracture union and consolidation, in this case of compound (Grade II) segmental fracture of ulna, the ulnar square nail was extracted and the bursitis subsided.

Dodge and Cady (1972) reported 4, 3.3%, cases of implant failure, in series of 119 cases of D.C.P. fixation, due to loosening of screws. There was one, 7.7%, case implant failure in form of breakage of ulnar square nail six months after its fixation, in Group I. There was no case of implant failure in Group II.

Marek (1961) treated 32 fractures of both bones of forearm with square nail fixation, achieved good results and formulated criteria for judging anatomical results in these cases from post operative and follow up radiographs. These criteria were modified and applied in our study. Marek (1961) had reported 4 cases, 12.5%, out of total of 32 cases of square nail fixation with poor anatomical alignment and poor func-
tional results.

Whereas in our study in Group I, there were 69.2% cases with good, 23% cases with satisfactory and 7.6% case with poor anatomical alingment. In Group II these were 80% good, 20% satisfactory and no poor anatomical results. Thus the anatomical results were better in Group II as compared to Group I.

Regarding the process of fracture union, Sage (1959) reported 6.2% non union in series of cases treated by intramedullary nail fixation. Caden (1961) reported 16.6% cases of non union in forearm fractures treated with intramedullary Rush pins. Marek (1961) reported a series of 32 patients treated by square nail fixation. He reported 4 cases, 12.5%, which went into delayed union and non union.

Anderson (1965) in his study on intramedullary nail fixation found that fracture union occurred promptly in fracture which were fixed rigid after open reduction. Delayed union or non union occurred when nail inserted was loose in marrow canal. Street (1986) reported 7% non union and 1.4% rate of delayed union in series of 137 cases treated by closed nail fixation.

According to Anderson (1973) criteria of fracture union, we had 1, 7.6%, infected non union in our Group I. There was no case of delayed union, where square nail fixation was used. The average time of union was 16 weeks and 3 days.

As regarding the rates of fracture union and fracture healing time with compression plate, there have been many studies
in literature. Anderson (1975) in their series of 244 patients treated by Muller's compression plates had 1.6% cases, which went into non union. The average time of union in his series was 7.4 weeks. Grace and Eversmann (1980) also used compression plate and reported 3.1% non union. Hadden (1983) used small fragment D.C.P. and reported 4% non union. Shah et al (1988) used small fragment D.C.P. and reported only 2.9% delayed and non union.

In Group II of our studies where small fragment D.C.P. was done there was no case of delayed or non union according to Anderson 1975 criteria. The average time of complete union was 14 weeks and 3 days but most of the cases, 60%, had fracture union by 9th week post operatively.

From his study in 1975 Anderson et al suggested that range of supination and pronation is the most significant indicator of the quality of results in fractures of forearm bones after the fracture had united. Only in few cases, the range of flexion and extension of wrist and elbow were affected in a significant manner so as to determine the quality of results. He suggested the criteria for assessing the the final quality of results which are described below:

Excellent: Union with excellent or (>75%) range of supination pronation and (>90%) range of flexion and extension at wrist and elbow.

Good: Union with >50% rotational arc and >80% flexion extension range.
Acceptable: Union with <50% rotational arc or <80% flexion and extension range.

Poor: Non union with or without loss of motion.

In his study he had 58.7% excellent, 30% good, 7.1% acceptable and 3.1% poor results.

In our study we have upgraded the range of maximum achievable rotational arc of forearm as 100% for excellent, more than 80% for good more than 60% for acceptable and less than 60% for poor results.

Using these modified criteria, we achieved Excellent results in 1 (7.7%) cases, Good results in 5 (38.5%) cases, Acceptable in 4 (30.7%) cases and Poor results in 3 (23%) cases in Group I. In Group II, the results were better with, 2 (40%) Excellent, 1 (20%) Good and 2 (40%) Acceptable results. There was no case with Poor results in Group II.

The routine removal of implant after fracture consolidation, either with square nail intramedullary fixation or with DCP fixation, has not been recommended by any author. Removal of implant has been suggested only if it causes some problems. Most common indications have been, olecranon bursitis due to protruded proximal end of ulnar square nail, restriction of movements of wrist when proximal end of radial square nail protrudes out. As regarding DCP, the subcutaneous location of the plate and repeated contusions of overlying tissue in some cases necessitates the removal of plate. Implant failure
is one other cause which would obviously necessitate the removal of implant either due to loosening of screws, or breakage of plate or breakage of nail due to metal fatigue.

Hidakas and Gustilo (1984) after a study of 32 plate removal suggested the protection of limb in A/E POP cast for 6 weeks after plate removal, so as to prevent the occurrence of refracture.

Bednar and Grandwiewisky (1992) suggested that plate removal must not be done earlier than 2 years after application of the plate, so as to minimize the chances of refracture.

In our Group II, during the follow up after fracture union, there were no complaints by patients due to the implant. Thus plates were not removed in any case on our series.

In Group I, during follow up, there were three cases where nails had to extracted. In one patient the protruded end of ulnar nail was causing olecrenon bursitis. The fracture had consolidated, therefore, the ulnar nail was removed and an A/E POP cast was applied for 6 weeks. In other patient, there was a deep infection which led to acute and later on to chronic osteomyelitis of both bones of forearm with two discharging sinuses. This case later on developed infected non union of fractures of both bones. In this case, radial and ulnar nails were removed, sinus were curreted and A/E POP cast was applied.

There was a third case where ulnar nail suffered fatigue breakage, approx. 6 months after operative intervention. In this case ulnar nail was replaced with a new nail, bone grafting was done
and A/E POP cast immobilization was given. The fracture of bone united thereafter and patient again achieved acceptable functional results.