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Fibular regeneration following fibulectomy in children-evaluation minimum two years after fibular harvest

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Abstract
Background the literature on fibular regeneration once procuring non-vascularized fibular grafts in child continuous to be scanty. The non-vascularized fibular graft has distinction of fibular regeneration occurring at the donor area.
Material and methods retrospectively analyzed the fibular regeneration at the donor leg following harvest of non-vascularized fibular graft. These patients had minimum 2 years follow up. The radiological regeneration was made in percentage by calculating the area of both operated and normal limb.
Results A total of 30 patients were evaluated. The average patient age was 9.56 years. No pain or neuromuscular deficit in the operated limb. The mean follows up of 39.4 months. The continuity of the fibula in the longitudinal was restored in 27 cases.

Keywords: Fibulectomy, fibular grafts, fibular regeneration

Introduction
The fibula is a good autogenous bone graft site in child. The non-vascularized and vascularized fibular harvesting have been an important to the pediatric orthopaedic surgeon. In the last few years, there has been a many of reports describing fibular regeneration and complications from vascularized fibular harvest in child. The morbidity most commonly being associated with vascularized fibular grafts [1–6]. One of the main reasons. The literature on fibular growth and its quantification after obtaining non-vascularized fibular graft in child is still a problem [7]. The non-vascularized fibular graft has differentiation from the vascularized graft as the fibular regeneration occurs at the donor site [7, 8].

Methodology
The retrospective study was conducted at NMCH, JAMUHAR conducted between April 2020 - May 2022. Ethical clearance obtained from the Institution's Committee. The operative details were jotted from patient's file records. Patients with age less than 12 years at the time procedure, who had undergone any of the orthopaedic operative procedure at least 2 years ago, utilizing non-vascularized fibular bone harvest were included in the study. Of all the included cases, maximum possible length of fibula was resected or cut. Patient with age > 12 yr at the time of index procedure or problems in donor leg or bony pathology in ipsilateral tibia or fibula and index procedures requiring smaller fibula graft lengths were excluded.
We extracted fibula using a periosteum preserving technique for fibular harvest and conserving a minimum of 10 % of total length at either fibular end to maintain ankle stability at distal end and for safety of deep peroneal nerve at proximal end of the fibula [9, 10]. Following the harvest weight bearing was restored after the subsidence of pain.
At follow up, all the clinical parameters were noted and fibular continuity, pain and neuromuscular deficits in the donor limb, if any present or not. The radiological parameters were done on digital x-ray machine and anteroposterior standing x-ray of both legs including knee and ankle joint with patella facing forward. After that the fibula divided in three equal parts in both the limbs. The diameters were measured at the junction of proximal & middle third as well as at junction of middle third & distal third. Mean diameter calculated and area measured using formula length*mean diameter.

The measurement was done for both operated as well as normal limb. Now the ratio of areas (regenerated fibular area/normal fibular area) was calculated and expressed in percentage.

Results

A total of 30 different and some of both ankles in 23 patients were evaluated for valgus deformity. The harvest of fibula was present bilateral in seven cases. The average age of the patient at time of follow up was 9.56 years (range, 5-14 years). The follow up and average age was 39.4 months (range, 24-83 months). The continuity of fibula in longitudinal dimension was restored to normal in 27/30 legs (90 %) by that time. Clinically, there was no sign of pain or neuromuscular deficit in the examined limbs at final follow up was present. Furthermore, there was also no symptoms related to harvest limb reported by any child.

Discussion

The non-vascularized bone graft has got very good potential of regeneration of fibula [8, 14]. Steinlechner and Mkandawire utilized non-vascularized fibular grafting for reconstruction of long bone defects after sequestrectomy in a case series of seven children. They had six fibulae with regrowth in continuity within 19.3 weeks (range, 6 to 75 weeks) [14]. The authors opined that early restoration of fibular continuity led to stabilization of the ankle in the donor leg and even suggested reutilization of regenerated fibulae [14].

The literature which was on fibular regeneration and other long-term effects on donor site after obtaining non-vascularized fibular graft in children is still very less [7, 15]. There was series of 23 children (24 harvested fibulae) with average age 8.9 years (range, 4-14 years) reported by González-Herranz *et al*. which showed incomplete fibular regeneration or non-union in 14 cases (58 %) [15]. There were radiological findings of distal migration of the fibula head in 18 cases (75 %, but without clinical relevance), lateral cortical tibial thickening in five cases (21 %), talar tilt in 11 cases (46 %), proximal migration of the distal end fibula in 13 cases (54 %), and diaphyseal valgus of the tibia in five cases (21 %). The average follows up which was in their series was 6.2 years (range, 4-11 years). The study however was quite heterogeneous with harvest of different anatomical fibular portions (head, proximal diaphysis, middle diaphysis, distal diaphysis, and lateral malleolus) and variable lengths of fibula graft (2-24 cm, average 9.9 cm). There was presence of primary tumour of fibula in seven of the cases. Half of their cases, the distal tibiofibular joint was stabilized and fixed with a suprasyndesmotic screw or a Kirschner wire. The Periosteum in all cases its preservation was not uniform [15].

There was another series on the harvest of non-vascularized fibula series by Xin *et al*. described 17 children with an average age in years (range, 2-13 years), and the mean follow-up was of 31 months (range, 7-65 months) [7]. The fibula was harvesting was done using a periosteum-preserving technique and methods. The variable lengths of fibula were harvested (average 28 %; range 10-58 %). The writers divided patients into two groups-nine harvest sites were filled with cancellous allograft and eight with calcium sulfate. There was no significant donor site complications were reported in this series with fibular regeneration being evident in all cases at a mean follow up of 12 weeks (range, 4-21 weeks) [7]. In our study we did not include the resection of either proximal or distal fibular epiphysis and there was a uniform surgical procedure with periosteal preservation which was used. The fibular graft site re- generation which was a natural process and we did not use any allograft or calcium supplements to augment the harvest site in any of our patients.

The fibular harvest was associated with several potential problems in a growing child. There was progressive ankle valgus and is one of the common deformities encountered after this procedure. The incidence of valgus deformity is reported to be 16.1 % according to Nathan [2]. Fragniere *et al*. found out that 45 % of children had ankle valgus after free fibula harvest. In their series, the deformities were severe in 25 % [6]. The morbidity has most frequently been seen from the vascularized fibular harvest series which they studied, where regeneration of donor fibular does not occur and what so ever, in several of these series, the main moto was oncological reconstruction requiring complete harvest of proximal or distal portions of fibula [1].

Nathan *et al*. instigated the timing of development of ankle valgus in vascularized fibular grafting [2]. The Children were first noted to have ankle deformity 32 months (range, 20-38 months) after their primary surgical procedures which was done earlier. In our series, we could not predict at what age the ankle valgus started developing as this retrospective analysis was done about 39.4 months (range, 24-83 months) after the main procedure. However, by this time 33 % ankles had already developed radiological valgus deformity. A previous report from our institution has prospectively has been analyzed the short-term donor site characteristics following non-vascularized fibula harvest [8]. There were 16 children with 21 harvested fibula. There was regeneration of fibula similar to the pre-operative dimensions as early as six months in 71 % of cases. The non-continuous regeneration (29 %) had no clinical implications including valgus in short term.

During weight bearing, approximately one-sixth of the weight is transmitted by fibula [16]. In a normal ankle, there is a uniform axial load applied to distal tibia and fibula results in the balanced growth of lower tibial epiphysis. In fibular gap non-unions, in weight-bearing positions, there is loss of a normal physiological load transmission through fibular side. Further, there proximal migration of the remaining distal fibula by the contracted fibrous scar around the gap (tethering effect). The epiphyseal growth at the lateral distal tibial epiphysis was inhibited by eccentrically ankle loading resulting in progressive ankle valgus [16]. The fibular resection also left behind mobile distal remnant which was not able to resist pressure from the talus during weight-bearing. In fact, shortening of the fibula, lateral wedging of the distal tibial epiphysis, and lateral tilt of the talus at the ankle mortise are supposed related closely [11]. Anatomical obliquity of the ankle mortise in a normal child before the age of 10 years, general laxity of ligaments in children and weakness present of tibialis posterior muscle are other factors postulated for ankle valgus [1, 2].

There were some limitations of our study. It was a retrospective study where initial and immediate post-operative radiographs of harvest site were not available. The calculation of fibular index was not possible. Comparing to a normal fibula this was possible only in unilateral harvest cases. The longitudinal dimension of fibula in anteroposterior radiographs was taken into account for calculation purpose. The strengths of the present study were a dedicated long term follow up the study was performed on a homogenous group consisting of only healthy fibular harvest graft patients (excluding pathological fibulae). These grafts which were harvested shared the uniform characteristics of a near total

fibular harvest that preserved proximal and distal epiphysis with a reasonable distal fibular support. Our study showed that radiological ankle valgus is a very common occurrence (33 %) even following non-vascularized fibular harvest. The presence of a regenerated fibula in continuous of (90 % legs) and almost of similar anatomical longitudinal dimensions (97 %) did not defer development of valgus deformity at ankle. The ankle valgus was found to be present despite of a normal Malhotra grading of 0 (patients 3, 4, 8, 10). Malhotra grading up to 1 may be considered normal in the growing children with some inherent laxity in ligaments (patients 1, 2, 6, 7, 9). Further, the abnormal Malhotra grading which was used in isolation did not predict fibular shortening or ankle valgus deformity. The non-continuity of regenerated fibula may be one of the factors for ankle valgus deformity but it is not an absolute indicator for its development (patient 12). The age of the patients also did not seem to influence the ankle valgus deformity (p = 0.35). Since, the development of ankle valgus deformity in children appears to be a delayed and a progressive event, there is a need to keep these children under regular the follow up. More research and understanding are needed to unlock the exact characteristics of this pathology.

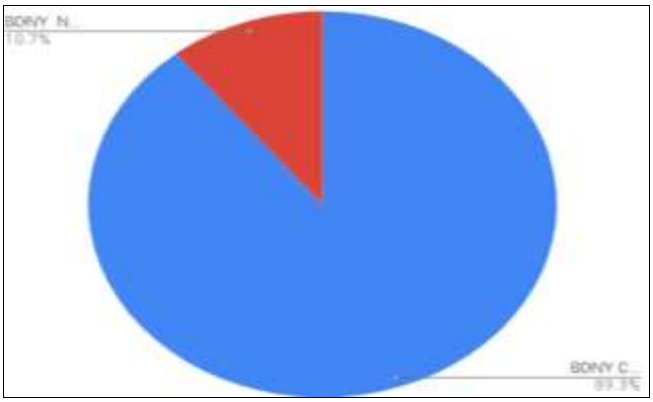

Fig 1: Shows Bony N 10.7 % and Bony C 89.3%

Conflict of Interest
Not available

Financial Support
Not available

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