

## Orthopaedic Oncology - Relevant articles in 2016

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This article encapsulates in brief the important publications pertaining to orthopaedic oncology that were published within the last year.

### Giant cell tumor:

An article by Benevenia et al looked at the outcomes in giant cell tumors (GCTs) following standard intralesional resection-curettage and adjuvant treatment using bone graft, with or without supplemental polymethylmethacrylate (PMMA).

[1] Complications evaluated included recurrence, fracture, and joint degeneration. Of the 43 patients included in the study 21 patients were reconstructed using femoral head allograft with or without PMMA and 22 patients were reconstructed using PMMA alone. At a mean follow up of 59 months (range, 12–234 months) non oncologic complications (articular fractures and osteoarthritis) occurred less frequently in patients treated with bone graft than those treated without (10% [two of 21] versus 55% [12 of 22]). With the numbers available, there was no difference in tumor recurrence between patients treated with bone graft versus without (29% [six of 21] versus 32% [seven of 22]). They concluded that compared with PMMA alone, the use of periarticular bone graft constructs reduces postoperative complications apparently without increasing the likelihood of tumor recurrence.

Gaston and colleagues have written an excellent overview on the current status of denosumab the new “wonder drug” for giant cell tumors. [2] Denosumab a monoclonal antibody to RANK ligand is recommended as the first option in inoperable or metastatic GCT. Denosumab has also been used

pre-operatively to downstage tumors with large soft tissue extension to allow for less morbid surgery. However the role of Denosumab for conventional limb GCT of bone is yet to be defined. Questions such as whether local recurrence rates will be decreased with the adjuvant use of Denosumab along with surgery and the long term use and toxicity of this agent still remain unanswered. They advise that complicated cases of GCT requiring Denosumab treatment should be referred and followed up at expert centres. So that further collaborative studies involving clinical trials and rigorous data collection may help to identify the optimum use of this drug.

### Chondroid lesions:

A study by Wilson et al looked at the prevalence and cost of unnecessary advanced imaging studies (AIS) in the evaluation of long bone cartilaginous lesions. [3] A total of 105 enchondromas and 19 chondrosarcomas arising in long bones were reviewed. Advanced imaging was defined as MRI, CT, bone scan, skeletal survey, or CT biopsy. Of patients diagnosed with an enchondroma, 85 % presented with AIS. The average enchondroma patient presented with one unnecessary AIS. The average unnecessary cost per enchondroma patient was \$1,346.18. Orthopaedic surgeons and radiologists need to be more pragmatic while recommending radiologic imaging in these patients as unnecessary AIS are frequently performed and are a significant source of expense. Central chondrosarcoma of bone can be divided into low-grade (Grade 1) and high-grade (Grade 2, Grade 3, and dedifferentiated) chondrosarcomas.

[4] Although en bloc resection has been the most widely used treatment, in selected patients with low-grade chondrosarcomas of long bones, curettage is safe and effective. This approach requires an accurate preoperative estimation of grade to avoid under- or overtreatment. Roitman et al evaluated the concordance of preoperative image-guided needle biopsy and postoperative findings in differentiating low-grade from high-grade central chondrosarcomas of long bones and its comparison with the concordance in central pelvic chondrosarcomas. Of the 126 central chondrosarcomas, 41 were located in the pelvis and the remaining 85 cases were located in long bones. The study considered 39 (95%) and 40 (47%) of them, respectively in which histological information was complete regarding preoperative and postoperative tumor grading. Concordance between the preoperative biopsy and the final pathological analysis in terms of histological grade was much higher in long-bone chondrosarcoma than in pelvic chondrosarcoma (83% [33 of 40] versus 36% [14 of 39]). The authors thus concluded that image-guided needle biopsy, when performed by a specialist radiologist and evaluated by an experienced bone pathologist, is a useful tool in determining the histological grade of long-bone chondrosarcomas allowing identification of true low-grade tumors. The same appears not to be true for pelvic lesions, in which histological grade established by needle biopsy should be interpreted with caution.

**Osteosarcoma:**

Chui et al set out to identify additional histologic variables of prognostic significance in high-grade osteosarcoma. [5] Slides of pretreatment biopsy and primary post neoadjuvant chemotherapy resections from 165 patients with high-grade osteosarcoma were reviewed. Univariate analyses confirmed the prognostic significance of metastatic status on presentation, primary tumor size, anatomic site, and histologic subtype. Additionally, the identification of lymphovascular invasion 10% or more residual viable tumor, and 10 or more mitoses per 10 high-powered fields assessed in post treatment resections were associated with poor survival, retaining significance in multivariate analyses. A prognostic index incorporating primary tumor size and site, and significant histologic features assessed on resection (ie, lymphovascular invasion status, mitotic rate, and extent of viable tumor) was developed. This scoring system segregated patients into 3 risk categories with significant differences in overall survival and retained significance in an independent validation set of 42 cases. Laitinen and colleagues evaluated the prognostic and therapeutic factors influencing the oncological outcome of parosteal osteosarcoma. [6] Eighty patients with a primary parosteal osteosarcoma had an overall survival of 91.8% at five years and 87.8% at ten years. Local recurrence occurred in 14 (17.5%) patients and was associated with intralesional surgery and a large volume of tumor. 80% of the local recurrences were dedifferentiated high-grade tumors. Medullary involvement by the lesion or the use of chemotherapy had no impact on survival while Local recurrence was a poor prognostic factor for survival. The authors concluded that the role of chemotherapy in the treatment of

parosteal osteosarcoma is not as obvious as it is in the treatment of conventional osteosarcoma and the mainstay of treatment is wide local excision.

**Ewing's sarcoma:**

A paper by Albergo and others questioned the traditional "cut off" ( $< / > 90\%$ ) between poor and good responders in patient's of Ewing's sarcoma who had chemotherapy. [7] Patients were grouped according to the percentage of necrosis after chemotherapy: Group I: 0% to 50%, Group II: 51% to 99% and Group III: 100%. There were significant differences in survival between the groups of necrosis: 0% to 50% (OS: 49% and EFS: 45% at five years, respectively) compared with 51% to 99% (OS: 72% and EFS: 59% at five years, respectively) and 100% (OS: 94% and EFS: 81% at five years. The authors concluded that only patients with 100% necrosis after chemotherapy should be classified as having a good response to chemotherapy because they have significantly better rates of survival compared with those with any viable tumor in the surgical specimen. This may have implications on the addition of adjuvant therapy in the post op period, both on the need to add local radiotherapy and intensify subsequent chemotherapy in the "poor" responders.

**Soft Tissue Sarcomas:**

Bonvalot et al evaluated the relationship between local control and overall survival (OS) in extremity soft tissue sarcomas (ESTS). [8] 531 consecutive patients with a median follow-up period of 7 years were reviewed. The 5-year actuarial local recurrence (LR) rate and OS were 8 % and 80 %. Predictors of worse OS were grade 3, leiomyosarcoma, male gender, and age, whereas tumor size, margin

status, and LR were not. In the multivariate analysis, specific subtypes (epithelioid sarcoma and myxofibrosarcoma) and margin size  $< 1$  mm correlated with LR, whereas grade and the tissue constituting the surgical margins did not. The authors thus concluded that specific subtypes and surgical margin size  $< 1$  mm correlated with a higher LR while neither the margin status nor LR affect OS. Thus specific subtypes (epithelioid sarcoma and myxofibrosarcoma), which demonstrated higher LR could require larger margins to offset their bad impact.

Smith and colleagues from the Royal Marsden Hospital evaluated 556 patients that underwent resection of primary extremity soft-tissue sarcoma. [9] They concluded that the local recurrence-free survival (LRFS) did not differ significantly between histological subtypes. Distant metastasis-free survival (DMFS) and disease-specific survival (DSS) were found to differ significantly between subtypes with the worst outcomes in patients with undifferentiated pleomorphic sarcoma. However, on multivariable analysis, histological subtype was not found to be independently prognostic for LRFS, DMFS or DSS. Metastatic disease developed in 149 patients, with the lungs being the most common site of first metastasis. The site of first metastasis differed between subtypes, with extrapulmonary metastases predominant in myxoid liposarcoma. This series suggests that the patterns of metastatic disease in extremity sarcoma are not uniform and histological subtype should be considered alongside other patient and tumor factors, such as tumor grade, size and patient age, in order to facilitate tailored follow-up regimens.

**Metastatic bone disease:**

Kim et al investigated whether closed intramedullary (IM) nailing with percutaneous cement augmentation was better than conventional closed nailing at relieving pain and suppressing tumors in patients with metastases of the femur and humerus. [10] A total of 43 underwent closed IM nailing with cement augmentation for long bone metastases. A further 27 patients, who underwent conventional closed IM nailing, served as controls. The mean pain scores of patients who underwent closed nailing with cement augmentation were significantly lower than those of the control patients post-operatively and the progression of the metastasis was suppressed in more patients who underwent closed nailing with augmentation compared to those in the control group. Thus percutaneous cement augmentation of closed IM nailing can improve the relief of pain and limit the progression of the tumor in patients with metastases to the long bones.

**Miscellaneous:**

An article from Japan compared the infection rates after reconstructing frozen autograft with non-coated implants and iodine-coated implants (group I). [11] Sixty-two patients were included in group N and there were 38 patients in group I. Among other complications deep infection occurred in 10 (16.1%) patients in group N and only in one (2.6%) in group I. The authors thus concluded that using iodine-coated implants for patients with malignant bone tumor minimized risk of infection. The importance of this article lies in the fact that this novel coating may have important implications extendible to joint replacements and implants used in trauma as well. Surgical resection of desmoid tumors has traditionally been the mainstay of

therapy, but this is a potentially morbid approach with high rates of recurrence. These tumors remain a management dilemma and the current trend has been towards conservative treatment rather than intervention. A retrospective analysis by Park et al identified 47 patients with a diagnosis of desmoid tumor from all anatomic sites. [12] 20 patients were managed with surveillance, 24 patients with surgery, and three patients with other approaches. Clinical and tumor characteristics between treatment groups were not significantly different. With a median follow-up of 36 months, there was one complete regression, five partial regressions, and 13 stable diseases among the surveillance group. Only one patient under observation progressed, crossing over to surgical resection. Among 24 patients managed with surgery, 13 patients developed local recurrence. There was a statistically superior progression-free survival in the surveillance group. This data further supports the currently held belief that an initial conservative approach to desmoid tumors that may spare patients the morbidity and risk of recurrence that accompanies potentially extensive operations.

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## Spine - Relevant articles in 2016 Arvind G. Kulkarni<sup>1</sup>

Mumbai is considered the Mecca for Spine Surgery. Many legends and centers have contributed immensely to the development of spine as a distinct specialty in Mumbai. Fittingly, this initial issue of the Bombay Orthopaedic Society edited by the illustrious Dr Nicholas Antao has delegated sumptuous space to literature on spine and spinal disorders. A journey through the past year's high impact factor- journals like The Spine Journal, Spine, JNS-Spine, European Spine Journal, Journal of Spinal Disorders and Techniques and the Global Spine journal reveals that the perspectives may change with time but the basics still remain the same. There has been an increasing talk among researchers about adjacent segment degeneration, clinically significant adjacent segment disease, issue of post-operative dysphagia after

anterior cervical surgeries, importance of natural history in spinal disorders, about the ever increasing scope of minimally invasive surgeries from the basic decompression to deformity corrections and the accuracy of pedicle screw insertion. This synopsis ends up with summarizing some significant contributions by Indian authors to the literature this year.

#### Adjacent segment Degeneration and Clinically significant adjacent segment Disease

Since fusion procedures have become so frequent the entities called 'adjacent segment degeneration (ASD)' and 'adjacent segment disease (ASDis)' are becoming issues of concern. Motion preservation surgeries, especially 'artificial disc replacement' was proposed as an alternative to fusion that had the potential to minimize the

incidence of ASD. Does it really do so in the long run is a million dollar question? Although there is no Level I evidence, in a meta analysis involving 1474 patients, Pan A and colleagues' [1] have evaluated the efficacy of motion preservation procedures to prevent ASD or ASDis compared to fusion procedures in lumbar spine. They indicated that the prevalence of ASD and ASDis and reoperation rate on the adjacent level were lower in motion preservation procedures group than in the fusion group. More over shorter stay in hospital was found in motion preservation group and no difference in terms of operation time, blood loss, and VAS and ODI improvement between the two groups. Another interesting paper on ASD throws light on the risk factors associated with the same. Heo Y et al [2] in their 10 years follow-up study of



401 patients where fusion surgeries were performed for spondylolisthesis at L4-5 or L4-5-S1 focused on risk factors that affected clinically symptomatic ASD (CASD). They evaluated six significant factors affecting CASD development. Among these risk factors, facet degeneration, isthmic-type spondylolisthesis, and the type of fusion show higher hazard ratios and seem to be clinically more relevant than the other three factors (age, overall lordosis, and segmental lordosis).

### **Minimally invasive decompression in lumbar degenerative spondylolisthesis**

The debate on the type of surgical procedure for degenerative spondylolisthesis goes on forever. Since conventional procedures for decompression involving surgical invasion of facet joints and surrounding soft tissue could increase instability and exacerbate clinical symptoms, decompression combined with fusion is generally recommended. Gen Mori et al [3] evaluated the outcomes in cases of lumbar degenerative spondylolisthesis at a follow-up of 5 years after treatment with minimally invasive decompression with examination of pre- and postoperative slippage, intervertebral disc changes, and clinical results. The hypothesis that this study relied on is the natural history of LDS and the preservation of anatomical structures in MED. The authors concluded that if minimally invasive decompression can be performed to treat LDS, it is believed that preoperative percentage slip and intervertebral disc degeneration do not have to be included in the appropriateness criteria for fusion.

### **Understanding Pedicle Screw misplacement**

Due to better primary stability and

repositioning options, pedicle screws are increasingly used during posterior stabilization of the cervical spine. However, the serious risks generally associated with the insertion of screws in the cervical spine remain. Bredow J et al [4] conducted a study to examine the accuracy of pedicle screw insertion with the use of 3D fluoroscopy navigation systems. Data of 64 patients were collected during and after screw implantation (axial and sub axial) in the cervical spine. 207 screws were implanted from C1 to C7 and analyzed for placement accuracy according to post operative CT scans and following the modified Gertzbein and Robbins classification. It was concluded that axial and sub axial screws can be inserted with a high grade of accuracy using 3D fluoroscopy-based navigation systems. Nevertheless, while this useful innovation helps to minimize the risks of misplacement, the surgery is still a challenge, as arising complications remain severe.

The accuracy rate of pedicle screw (PS) placement varies from 85% to 95% in the literature. This demonstrates technical ability but does not represent the impact of screw misplacement on individual patients. A retrospective study conducted by Sarwahi V et al [5] quantifies the rate of screw misplacement on a per-patient basis to highlight its effect on potential morbidity. Of the 2724 screws placed in 127 patients, a total of 2396 screws were accurately placed (87.96%). A total of 247 screws (9.07%) were benign misplaced, 52 (1.91%) were intermediate misplaced, and 29 (1.06%) were considered in screw at risk (SAR) group. Per-patient analysis showed 23 (18.11%) of patients had all screws accurately placed (AP), thirty-five (27.56%) had IMP and 18 (14.17%) had SAR. Per-patient analysis reveals more concerning numbers toward screw

misplacement. With increasing pedicle screw usage, the number of patients with misplaced screws will likely increase proportionally. Better strategies need to be devised for evaluation of screw placement, including establishment of a national database of deformity surgery, use of intra-operative image guidance, and reevaluation of postoperative low-dose CT imaging.

### **Oswestry Disability Index [ODI]**

ODI has long been used to study the outcomes of patients suffering from lumbar degenerative disorders. A significant reduction in ODI scores is an index of patient's satisfaction and reduction of disability, although there has not been quantification for the same as to what value indicates as being significant. Van Hooff ML et al [6] suggested an ODI score  $\leq 22$  indicates the achievement of an acceptable symptom state and can hence be used as a criterion of treatment success alongside the commonly used change score measures. At the individual level, the threshold could be used to indicate whether or not a patient with a lumbar spine disorder is a "responder" after elective surgery.

### **Knee-up test**

Post-operative neurological deficit is one of the complications of spine surgery that is most dreadful for the surgeon as well as the patient. Efforts have been put since years to reduce this complication. One of the simplest ways to detect if such an event has occurred before extubation of the patient is a Knee- Up test. Yugue et al [7] conducted a prospective study of 521 patients where the patient's knee is passively lifted up and the patient is able to maintain this position in both legs, the result is negative, whereas when the patient is unable to maintain the knee in an upright position for one or both legs, the result is positive. The

sensitivity, specificity, positive predictive value, and negative predictive value were 88.9, 99.8, 94.1, and 99.6, respectively.

### **Parkinson's disease (PD) and cervical myelopathy**

Parkinson's disease (PD) is a common movement disorder in elderly patients and co-existence with cervical myelopathy complicates the situation. There have been questions about the efficacy of surgery in such patients and thus providing them with a better quality of life. Xiao R et al (The Spine Aug 2016) conducted first study to characterize QOL outcomes following cervical decompression and found significant reduction in pain-related disability was observed following decompression. However, PD predicted diminished improvement in overall QOL measured by the EQ-5D.

### **Novel approach for lumbar interbody fusion**

Lumbar interbody fusion is being long used as the method of choice in lumbar degenerative disorders and is most commonly done through posterior approaches (PLIF and TLIF). The direct anterior approach requires mobilization of the great vessels to access the intervertebral disc spaces cranial to L5/S1. Molloy et al [9] came up with a novel extensile anterolateral retroperitoneal approach for lumbar interbody fusion from L1 to S1 which is safe, muscle-splitting, psoas-preserving, one-incision approach and thus revolutionize interbody fusion technique.

### **Glass ceramics spacers**

Constant efforts are being made to improve the fusion rates in patients suffering from lumbar degenerative disorders. The most recent advent is the CaO-SiO<sub>2</sub>-P<sub>2</sub>O<sub>5</sub>-B<sub>2</sub>O<sub>3</sub> glass ceramics spacer. Lee JH et al [10] found that ceramics spacer showed a

similar fusion rates and clinical outcomes compared with titanium cage however, the bone fusion area directly attached to the end plate was significantly higher in the bioactive glass ceramics group than in the titanium group.

### **Anterior Cervical surgeries and the role of steroids**

Dysphagia is a common post-operative symptom for patients undergoing anterior cervical spine procedures. Siasios I et al [11] studied the current literature regarding the effect of steroid administration in dysphagia after anterior cervical spine procedures through a literature search. Steroid administration protocol involved dexamethasone in few, Methylprednisolone in others. In four studies, steroids were applied intravenous, while in one study, locally in the retropharyngeal space. Short-term dysphagia and prevertebral soft tissue swelling (PSTS) were diminished by steroid administration, according to the results of two studies. In one study, prevertebral soft tissue edema was not affected by the steroid usage. Furthermore, short-term osseous fusion rate was impaired by the steroid administration, according to the findings of one study. After a review of 44 patients undergoing multilevel (2-, 3-, 4-level) ACDF, 22 of which received RP steroid, Koreckij TD et al [12] noted a trend toward decreased PSTS on initial postoperative radiographs, but was no longer evident at 6 weeks. NDI, although improved from pre-operative scores, failed to demonstrate significant differences between groups. Locally delivered methyl prednisone did not result in increased rates of short-term postoperative complications

### **Top 100 cited article in cervical spine surgery**

Cervical spine surgery is a rapidly evolving and challenging subspecialty that owes its advancements to many individuals and their pioneering works that have shaped the way we practice modern cervical spine surgery today. A study conducted by Branko Skovrlj et al [13] identifies the authors and 100 topics that made the greatest impact in the field of cervical spine surgery over the course of the last century and the beginning of this century. The top article was cited 826 times; the 100th article, 133 times; and the mean number of citations for the top 100 articles were 203.6. The oldest article was by Rogers published in 1957. The newest article was published in 2009 by Murrey et al. Eighty-three percent of the top 100 cited articles were published after 1980, with the 1990s producing the largest number of highly cited articles (35%). The top 100 articles were published in 18 journals, with the top three journals publishing 72% of the articles. The top journal was Spine with 39 articles followed by the Journal of Bone and Joint Surgery American Volume with 20 articles and the Journal of Neurosurgery with 13 articles. The three most popular categories were cervical spinal fusion with 17 articles, surgical complications with 9 articles, and biomechanics of the cervical spine with 9 articles. Eighty-six first authors contributed to the top 100 articles. Only three authors were credited with three or more publications and only one author, Abumi, had four publications in the top 100. The top articles originated from nine different countries, with the United States (65%) being the most prolific. There were 61 institutions responsible for the top-cited articles with Hokkaido University in Sapporo, Japan contributing the most articles with five publications in the top 100.

### **Prediction of posterior ligamentous**

### complex injury in thoracolumbar fractures using non-MRI imaging techniques.

Rajasekaran S and colleagues [14] formulated a radiological index based on plain radiographs and computer tomography (CT) to reliably detect posterior ligamentous complex (PLC) injury without need for MRI. They assessed thoracolumbar fractures with doubtful PLC with MRI, CT and radiographs. PLC injury was assessed with the following radiological parameters: superior-inferior end plate angle (SIEA), vertebral body height (BH), local kyphosis (LK), inter-spinous distance (ISD) and inter-pedicular distance (IPD) and correlated with MRI findings of PLC injury. They proposed that on plain radiographs the presence of LK greater than 20° and ISD difference greater than 2 mm can predict PLC injury. These guidelines may be utilized in the emergency room especially when the associated cost, availability and time delay in performing MRI are a concern.

### Irreducible AAD

SK Srivastava et al [14] demonstrated an excellent technique for a difficult problem. The study reinforces the safety and efficacy anterior release for reduction of IAAD. They concluded that anterior release followed by instrumented posterior fusion is a safe and effective modality of treatment for IAAD associated with basilar invagination. This opens up a new avenue for this difficult problem.

### Clinical efficacy of tapered rods in posterior cervicothoracic instrumentation

The cervicothoracic spine is a junctional area with complex biomechanics. Kulkarni AG et al [15] analyzed the efficacy of tapered rod system in clinical scenarios in the short term. In their study no biomechanical failure occurred in any of the 14

patients and intraoperative complications were noted in none. This is the first study on the efficacy of tapered rods and demonstrates that tapered rods are an excellent and a viable option to connect screws to stabilize cervicothoracic junction in the short term.

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## Growth Modulation for Angular Deformities around the Knee: Literature Review

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Growth modulation for angular deformities in the limbs in paediatric age group has been known for many decades [1]. Phemister had described his method of epiphyseodesis in the early 20th century [2] and Blount popularized his method of epiphyseal stapling which became the treatment of choice for hemi-epiphyseal growth modulation for many years [3]. However, both these methods caused permanent epiphyseodesis and were also associated with significant complications related to the implants and instrumentation [4-7]. This scenario changed drastically with the introduction of the revolutionary "8-plate" or "tension-band plate" by Dr. Peter Stevens in 2007 [8]. This "8-plate" was a low-profile, easy to use and relatively inexpensive implant and had the biggest advantage of causing minimal disturbance of physeal and periosteal blood supply- thus making it an ideal choice for temporary hemi-epiphyseodesis for correction of

angular deformities at any age before skeletal maturity. The early results of this method were uniformly encouraging and it gained widespread acceptance over the next few years. However, as with any new method, more and more usage meant more and more nuances were understood of the method and clinicians all over the world started sharing their experiences, difficulties, modifications and technical tips about these tension band plates [9-12]. This has led to a preponderance of literature about this topic over the last few years. It is our endeavor in this article to put forth a brief summary of the recent literature related to 8 plates as regards Biomechanics, results, Failure, comparison of various implants and use in pathological physes.

#### Biomechanics:

A number of articles have been written about the various biomechanical aspects of hemiepiphyseodesis. Since the basic scientific explanation by

Hueter in 1862 about the phenomenon of mechanical manipulation of bone growth [13] as well as Volkmann's description of asymmetrical growth of the physis [14], these two articles have formed the basis of the concept of epiphyseal stapling and hemi-epiphyseodesis for deformity correction.

Over the last decade and a half, various authors have described many animal models about stimulation and manipulation of physeal growth. One of the best studies which described the pros and cons of hemiepiphyseal stapling versus other methods of growth modulation was described by Aykut in 2005 [15]. In his study, he compared sub-periosteal placement of staples to extra-periosteal placement in an animal model and found extra-periosteal placement to be better in terms of reliable correction as well as physeal growth after removal. This led to the start of the research for a more reliable and reversible method of



epiphyseodesis which can be applied extra-periosteally (as against staples which require sub-periosteal placement).

Peter Stevens first put forth his series of patients with angular deformities of the knee treated with 8-plate

epiphyseodesis in 2007 [8]. As a follow-up to that article, he also published a very important basic science/animal model article in 2008 [16]. He had then stated that at least as per animal studies, 8 plates and staple systems have equivalent rate of correction but with the 8 plates being the method with theoretically lesser complications. This was a time when the 8 plates were just being introduced and there was still a question whether the correction was as good as the epiphyseal staples.

Another article by Sanpera et al [17] also put forth an interesting proposition. In this article published in 2012, the authors put forth the importance of the single tether which was more effective in the angular correction of deformities rather than the implant itself. This article showed that the 8 plate applied singly is equally effective with a single staple, but is more effective than the double staples which are more commonly applied. Hence the authors have commented that 8 plate works as a single tether on which the correction takes place. Thus they have said that it is better to put a single staple rather than put a double one.

One of the latest article about basic biomechanics about growth modulation was the one written by Schoenleber et al in 2014 [18]. This article studied the very important topic of screw size, number and configuration in a bone model. They concluded that screw size and number had no effect on the rate of angular correction but described the configuration of screws to be the most important. The authors have stated that parallel screws are the

best as regards the rate of angular correction as compared to divergent screws. This is very important clinically and has advised the clinician about perfectly parallel placement of the screws for better correction.

### Results/ Comparison

The minimally invasive techniques of epiphyseodesis viz Blounts stapling, screw epiphyseodesis and 8 plate epiphyseodesis have made this procedure much more simple, predictable and technically less challenging than the epiphyseo-metaphyseal fusion as proposed by Phemister [2].

Haas described reversible retardation of the physal growth with his wire loop technique, mostly in animal experiments but also in a small number of patients [19]. Based on his work, Blount and Clarke described their early results of physal stapling in 1949 [3] and this method revolutionized the treatment of angular deformities especially around the knees in paediatric patients. The technique evolved over the years and two extra-periosteal Vitallium staples became the standard of care for a number of years. During the course of many years, many authors then started showing their own results of Blounts stapling which were not as good as those shown by Blounts own unit [6-7]. Though experimentally, Blounts staples were shown to retard but not stop physal growth, a number of patients developed permanent epiphyseodesis. Also, since the plates needed to be hammered in, the extra-periosteal placement of the plates used to become sub-periosteal and hence physal bars were commonly seen. The other important complications of the Blounts staples were the three "B's" i.e Backing out, Breakage and Bending. This led to a number of difficulties in the long term outcome of staples leading people to look for better alternatives.

The other main problem with Staple epiphyseodesis used to be its timing<sup>1</sup>. A number of complicated methods of predicting the time for epiphyseodesis have been developed namely the Green-Anderssens charts, Multiplier methods etc [20]. There used to be significant problems with using these methods. The accuracy of most of these methods is similar, with significant inter-and intra observer variability. Hence clinicians started looking for a more reversible method of epiphyseodesis which does not cause any permanent damage to the physis. Peter Stevens published his series of patients with angular deformities in the knee treated with his new "8-plate" system [8]. The 8-plates were small, low-profile, two-hole plates with a small central hole for the guiding hole for the physis. Two screws are placed- one on each side of the physis and the plate is necessarily placed in the extra-periosteal fashion. The screws have got good anchorage in the cancellous meta-and epi-physal bone and the screws can diverge at the screw-plate interface as the physal growth occurs at the other end of the physis. Due to this, the incidence of back-out, bending and breaking of the screws is much less as compared to the staples. Due to the extra-periosteal nature of the implant, there is very little chance of a physal bar formation and hence very little chance of permanent epiphyseodesis. Also, as a single extra-periosteal plate is sufficient for all but one indication (correction of flexion deformity of the knee), the application of the 8-plate is simple and can be done without much difficulty even in the most distorted anatomy. This multi-faceted feature of the 8-plate was a great improvement over the staples and this has led to a rapid expansion of indications for epiphyseodesis and a renewed interest in this field. A number of authors then described the good early results of this simple to use technique. Ballal et al

described their results of hemiepiphyseodesis for genu valgum and showed good to excellent correction in most of the patients [21]. Many researchers have also endeavoured to find out the average rate of correction with femoral and tibial 8-plates. On an average, the rate of correction for a femoral 8plate is about 0.7-0.9 degrees per month, 0.5-0.6 degrees per month for the tibia and about 1.4-1.6 degrees per month for both femur and tibia [3,21,22].

However this rate depends on the age of the child, menarchal status in the female as well as rate of overall growth of the child.

There has been a growing consensus that the 8-plate has superseded the staple. However there have been only a few prospective studies which have directly compared 8-plates with the staples. Two of the earliest articles comparing to methods of epiphyseodesis were by Weimann et al [23] (which was a comparative analysis in patients) and Goyeneche et al [24] (which was an animal experiment). Both studies concluded that 8-plates were almost equivalent in the magnitude and degree of correction though 8-plates had better adherence to the bone as compared to staples and this was very useful in preventing back-outs which were very common with staples.

Another very high quality article by Gotleibsen et al has described the results of a randomized control trial comparing the 8 plates with staples [25]. This article showed equivalent results of 10 patients treated with staples as compared to 10 patients treated with 8 plates in terms of rate of correction, complications as well as pain scores with the difference being statistically insignificant. This was a very important article which proved that even though the primary results of 8 plates are good and the 8-plate as a system is very easy to use, modular and

low-profile, actual improvement over the old system has not been documented and hence stapling still remains the gold standard as far as growth modulation is concerned. The search is still on for a study which emphatically proves the superiority of the 8-plates over the staples.

Failures and special situations:

After the great initial enthusiasm about the 8 plates, there was a rampant use of this method in a large number of indications which included not just idiopathic (or nutritional) angular deformities but also conditions with pathological and sick physis. The results of these series were not that encouraging and the initial euphoria was slightly dampened by these results.

Blounts disease is one condition in which 8-plates were used quite frequently. However Schroerlucke et al were one of the first to describe their series of patients of Blounts disease treated with 8 plates [9]. In this series, there was a failure/complication rate of as much as 44% which was unacceptably high. Another article from the Baltimore group also put forth similar results especially in obese patients with Blounts disease [11]. They also said that it is the metaphyseal screw which almost always breaks and the breakage is at the level of the screw bone junction and not the screw plate junction. Thus they have suggested that especially in obese kids, it is best to use solid noncannulated screws to prevent such complications and failures.

Another article by Masquijo et al in 2016 [10], discussed the causes of failure in a heterogenous group of patients of which the commonest was hypophosphatemic rickets. A few others have described their results in pathological physes with mixed results. Dr. Peter Stevens from Utah has one of the highest number of patients with pathological physes treated with 8 plates and he has shown good results in a select group of patients [26]. Some

other authors like McKenzie et al from DuPont institute [27] and Grill et al [28] have also shown their results in skeletal dysplasia, Hypophosphatemic rickets, etc. The most prominent advantage which has been cited by these authors is the fact that 8-plates can be safely used in very young children without any risk of permanent physeal damage which is a very important factor in skeletal dysplasia where the rate of growth is very poor.

### Summary:

- Growth modulation for angular deformities around the knee is a very important tool in the armamentarium of the orthopaedic surgeon.
- With the advent of the 8-plates, this procedure has become safe, easy to reproduce and with very few complications.
- Extra-periosteal placement of a single tether (8-plate) is the most important factor in producing the best results.
- The screws have to be placed parallel for the best correction rather than convergent or divergent.
- The average rate of correction is about 0.7-0.8 degree per month for femur, 0.5-0.6 degrees per month for the tibia and 1.4-1.6 degrees per month for both simultaneously.
- 8-plates can definitely be attempted in pathological physes like Blount disease, hypophosphatemic rickets, Skeletal dysplasia etc, though the rate of correction is much less predictable and failure rate is relatively high.

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