

Role of Mesenchymal Stem Cells in Distraction

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Stem cells discovery is an important phase of molecular and cell biology and its ability to self-renewal and differentiations into specialize tissue stem cells. The recent advances in tissue engineering molecular cell biology and stem cells application in cardiology, endocrinology, neurology, traumatology and reconstructive bone grafting and other application in Maxillofacial surgery, these stem cells been a feature of paediatric surgery, orthopaedic surgery and cranio-maxillofacial surgery and temporo-mandibular joint reconstruction and jaws bone in children through varieties of surgical procedures.

The advancement of craniofacial surgery happened during the last five decades was by application of bone grafting and distraction osteogenesis and modern instrumentation to facilitate the surgical technique, beside advancement of radiographic examinations technique including 3D CT scan and MRI.

Distraction is the process of generating new bone by stretching osteogenesis, traction on living tissue stimulate and maintain regeneration and growth by inducing proliferation of precursor cells.

The history of Distraction Osteogenesis begins with old technique of repositioning and stabilization of bone fractures used by Hippocrates [1] and first described by Codi villa (1905) [2] who published a case report for elongation of bone of the femoral extension by using axial forces of distraction.

This recent Distraction technique was advocated by great Russian orthopaedic surgeon by Gravlín Illizarov [3] this Russian surgeon developed innovative devices for skeletal fixation and osteotomy technique that deliver minimal trauma to the periosteum and to the bone marrow, his statement that gradual traction applied on living tissue can stimulate and maintain regeneration and active growth.

The story of illizarov [4] technique was advocated for managements of limb shortening in children and also after the second world war illizarov [3] faced soldiers with loss bone of the limbs, this situation encourages illizarov [3] to advocate his technique for managements of elongation of short unequal limb length. In 1980 McCarthy [5] used this technique to treat hemi facial microsomia and small chin or micrognathias in children, others they did use this technique to treat craniofrontonasal dysplasia, craniosynostosis as well as airway obstruction featured in new borne babies featured as gloosoptosis with micrognathias and cleft palate nominated as Pierre Robin Syndrome and bilateral external distractors been used for elongation of lower jaw and making room for accommodation of large tongue preventing to obstruct the airway.

For long time in orthodontic treatment they use a splint to cover the palate with screw divided into half or 3 part fixed on crown of upper first molars teeth by turning the screws every week once to achieve 1 mm widening in width and in length, these device I think was a distractor based on illizarov [3] principle. This technique was used in children with class III male occlusion for advancement of upper jaw and to prevent future major surgery for correction of skeletal jaw relationship.

Tissue engineering research solve many problems in deformities of craniofacial and orthopaedic surgery.

Distraction process of elongation of bone by stretching mechanism of periosteum and muscle after osteomised the cortex of the bone. The pioneer of work of illizarov [4] and his technique was designated for elongation of lower limbs in children but before that illizarov discovered this technique after the second world war when he faced soldiers suffering from short leg. In the early ninety McCarthy did use this technique for elongation of the mandible in children suffering from First Arch Dysplasia Syndrome.

Distraction osteogenesis (DO) is also called callus distraction and also different names given to distraction such as callotasis and osteodistraction a process used and applied in orthopaedic surgery and oral and maxillofacial surgery to repair skeletal deformities and reconstructive surgery also been used for advancement the frontal bone, anterior cranial fossa and orbit in cases like Cranio-frontal-Nasal dysplasia [7,8].

Also been used in Pierre Robin Syndrome with cleft palate, glossoptosis and micrognathia by advancing the small mandible by external distractor device with surgical plate to cover the cleft palate and to prevent the milk from Brest nipple of the mother by making negative pressure, this mechanism aid in sucking from the mother nipple, the distractor used to advance small mandible forward to prevent the tongue to obstruct the airway and making a room site in the floor of the mouth for the large tongue.

In the past we did use glassopoxy technique by pulling the tongue forward by passing a silk suture size 0 transversely between posterior third and anterior 2/3rd and sutured to the chin. By this technique we did prevent large tongue to go back and blocking oral airway, also feeding aid plate reconstructed to cover the cleft palate, the child should lie on his tomy and pillow below his shoulder and lower jaw should be free. Feeding should done while the child lying on his abdomen and the head on side to prevent suffocation.

The distraction techniques 6 were passing through three phases, phase one is the surgical phase, in this phase distractor device fixed to either long bone or to the lower jaw and creation of osteotomy of the bone. The second phase is the key point in distraction success and a critical phase called Latent Period phase, started by formation of clot in the osteotomised part of the bone with formation of granulation tissue and releasing of growth factor from the platelets (PGF) and mesenchymal stem cells from the bone marrow of stumps of bones and formation of fibrous tissue oriented in the same direction of the stretching force and osteoid tissue.

These cellular changes occurred during the latent period phase which elapsed between 3 - 7 days, this phase followed by the third consolidation phase, were maturation of newly bone and osteoid tissue occurred and elapsed about 6 weeks.

We did the pioneer work, 6 by testing the distraction phenomena by experimental studies on Rabbits as animal model, these animals were subjected to experimental studies by distraction for elongation of the mandible by using bilateral distractor designed for small bone lengthen and adjust by Kirschner wire of 1.5 mm passed through mandibular body, rhythmed distraction of both cortectomies fragments rate of 1 mm/day at rhythmic of 0.5 mm twice daily preceded by Latent period for 7 days and distraction period for 10 days.

The result of this experimental work after consolidation phase for 6 weeks, we achieved 10mm of mandibular lengthen.

Surprising thing we did experimental studies on Rabbits by resecting a piece of bone of 1.5 cm from lower border of Rabbit mandible and immediate reconstruction by apiece of bone from iliac crest of Rabbit of about 2 cm after decortication of both the segments of the mandible and bone graft, the graft was fixed to the mandible by soft stainless steel wire of 0.25 mm by rigid fixation.

The histology and cytological changes of Distraction and Bone Grafting was quiet interesting and showed formation of clot and platelets aggregation with releasing growth factor (PGF) and healthy granulation tissue formed with releasing of mesenchymal stem cells from bone marrow, periosteum and covering muscles with formation of large amount of fibroblast, tiny blood vessels and also osteoblast with chondrocyte [6-8].

The only differences between Distraction and Bone Grafting, the distraction induced by stretching of tissue and bone graft by decortication of both stumps and bone graft with rigid fixation.

Conclusion

By this pioneer and original research experimental work, we did prove the role of mesenchymal stem cells and PGF in distraction for lengthening of long bone and its application in Craniofacial and Orthopaedics Surgery and also the role of mesenchymal stem cells in bone grafting.

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