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Review Article

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RING FIXATORS BETWEEN THE PAST AND THE PRESENT.

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Abstract:

In this review paper we have discussed the evolution of ring external fixators over time and the development of newer technologieswe also included review of some literature The aim of this review is to highlight the mechanical differences and the overall outcome whether following deformity correction or treatment of compound fractures between the different versions of ring fixators as well as a comparison between uniplanar and ring external fixators for management of compound fractures.

Keywords: Comparison between ring fixator, Development of ring fixators, Ilizarov, Ring fixators، TSF

Definition of ring fixator:

A type of external fixation used in orthopedic surgery to lengthen or reshape limb bones; as a limb-sparing technique to treat complex and/or open bone fractures; and in cases of infected nonunions of bones that are not amenable with other techniques.[1]

History:

The origins of using ring fixators with tensioned wires to treat orthopaedic injuries are inextricably linked with Gavriel Abramovitch Ilizarov (Figure 1). He was a Soviet Surgeon who was born in Poland in 1921 and grew up in modern day Azerbaijan, near the border with Dagestan. He went to medical school in Simferopol in the Crimea, and was sent to a rural hospital in the province of Kurgan. He became a surgeon in the regional hospital in Kurgan itself in 1950.[2]

Figure 1: Gavriel Abramovitch Ilizarov.

Where did the idea come from??:

It is difficult to separate fact from myth, when looking at the origins of the circular frame and the ideas of Ilizarov. Some people believe that the idea came from looking at the spoke of a cycle wheel, while others believe that his ideas were much more due to considered thought and pragmatic treatment of war veterans, and less due to a single moment of inspiration. At the time, there were tens of thousands of men and women who had been injured in the war, and who could not be treated by conventional means due to infection, limited surgical equipment and expertise. Kurgan was also a centre for engineering in the Soviet era, and the availability of high quality steel means that the idea of using actual bicycle spokes may just be a myth.[2]

Mechanics and Physics:

The device is a specialized form of external fixator (Figure 2), a circular fixator, modular in construction. Stainless steel (or titanium) rings are fixed to the bone via stainless heavy-gauge wire (called "pins" or Kirschner wires).

Figure 2: Ilizarov External Fixator

The rings are connected to each other with threaded rods attached through adjustable nuts. The circular construction and tensioned wires of the Ilizarov apparatus provide far more structural support than the traditional monolateral fixator system. This allows early weightbearing.

The apparatus is based on the principle which Ilizarov called "the theory of tensions". Through controlled and mechanically applied tension stress, Ilizarov was able to show that the bone and soft tissue can be made to regenerate in a reliable and reproducible manner. The top rings of the Ilizarov (fixed to the healthy bone by the tensioned wire) allow force to be transferred through the external frame (the vertical metal rods), bypassing the fracture site. Force is then transferred back to the healthy bone through the bottom ring and the tensioned wires. This allows the Ilizarov apparatus to act as a sort of bridge, both immobilizing the fracture site and relieving it of stress, while allowing for the movement of the entire limb and partial weight-bearing. Middle rings (and tensioned wires) act to hold the bone fragments in place and to give greater structural support to the apparatus and limb. However, the critical load bearing rings are the top and bottom rings which transfer the force from the healthy bone down to the healthy bone, bypassing the fracture site.[3]

Hexapod Fixators:

Dr. Charles Taylor, an orthopedic surgeon from Memphis, advanced the Ilizarov frame by connecting the two rings with six telescopic struts (instead of the four threaded rods) that can be independently lengthened or shortened to bring the two rings to any desired position. Furthermore, he developed a computerized way to correct deformities by combining several engineering principles.

The frame was named the Taylor Spatial Frame (TSF) (Figure 3 A) and was made by Smith & Nephew (London, United Kingdom) under the patency law agreement

The patency of TSF expired three years ago, opening the door for three more devices to be introduced to clinical practice (Figure 3-B), namely, Orthex by OrthoPediatric (Warsaw, Indiana),the Multi-Axial correction system (MAX frame) by Depuy Synthes (Warsaw, Indiana)[4] and the TrueLok Hexapod (TL-HEX) by Orthofix (Lewisville, Texas) that also developed The web-based TL-HEX software that supports surgeons throughout pre/intra/postoperative phases, and The HEX-Ray module which is designed to facilitate preoperative planning and postoperative monitoring with TL-HEX Software 2.3, with the direct upload of digital X-ray images into the software (Figure 4). It provides a suggested lengthening calculation option, anatomical angle indication for femur and tibia, the possibility to define osteotomy level, and the related translations[5]

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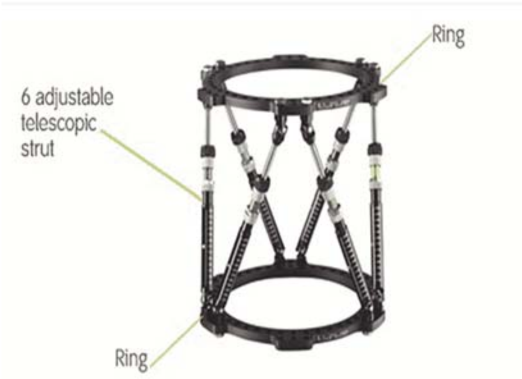

Figure 3 A: TSF

Figure 3 B : Different Types Of Ring Fixators

Figure 4: TL-HEX Software

Physics and mechanics of TSF :

The device consists of two or more aluminum or carbon fiber rings connected by six struts. Each strut can be independently lengthened or shortened to achieve the desired result, e.g. compression at the fracture site, lengthening, etc. Connected to a bone by tensioned wires or half pins, the attached bone can be manipulated in three dimensions and 9 degrees of freedom. Angular, translational, rotational, and length deformities can all be corrected simultaneously with the TSF.

Others have the same principles with minor modifications in the software and hardware according to the manufacturing company.[6]

Literature Review:

Aim: is to highlight the mechanical differences and the overall outcome whether following deformity correction or treatment of compound fractures between the different versions of ring fixators as well as a comparison between uniplanar and ring external fixators for management of compound fractures.

In the cost-conscious era: Ilizarov circular frame or uniplanar external fixator for management of complex open tibia shaft fracture, retrospective cohort study from a level-1 trauma center

Objective: This study was conducted to determine the outcome of open tibia shaft fracture treated with either Ilizarov or AO External Fixator.

Methods: A non-commercial retrospective cohort was conducted at Aga Khan University Hospital Karachi on patients operated for isolated open tibia fractures Gustillo type III (A, B, C) stabilized with external fixation either circular or uniplanar external fixator. These two groups were compared in terms of fracture pattern, healing and complications. For fracture healing, Radiographic union score (RUST) for tibial fractures was used.[7]

Results: A total of 93 patients were included in the study. Mean age 36.7 +/- 17.3 years comprising 83 males and 10 females. Circular Fixator was used for 46 whereas 47 were treated with uni-planar fixator. Mean new injury severity score was 21 ± 3.4 for circular fixator group and 26 ± 7 in uniplanar fixator group. Mean time for fracture healing was 6±1months in circular fixator group and 9 months in Uniplanar Fixator group. Mean RUST score for circular fixator was 9.5±1.2.and of uniplanar it was 7.3±1.0.

Conclusions: Circular fixator works as a single stage procedure with acceptable outcomes for Gustilo grade III open tibial shaft fractures as compared to uniplanar external fixator.[7]

Comparison of Three Circular Frames in Lower Limb Deformity Correction: A Biomechanical Study:

Methods

This is a biomechanical study comparing the three types of circular frames to correct similar deformities in Sawbones models. These frames are the Taylor Spatial Frame (TSF; Smith & Nephew, London, United Kingdom), the Truelok Hexapod System (TL-HEX; Orthofix, Lewisville, Texas), and Orthex (OrthoPediatrics, Warsaw, Indiana).The deformities that are compared

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were: (1) 30° valgus deformity of the distal femur; (2) 30° varus deformity of the proximal tibia.

Each frame was applied to the deformed bone in the standard way that we apply to normal bone. X-rays were taken before and after the deformity correction. The frames' software was used to estimate the deformities. The variations between the software's estimations and the known bone deformities were compared. Residual deformity after initial correction and the number of re-programmings was compared among these three frames. The least residual deformity and re-programming is the favorable outcome.

Conclusions:

The three frames were comparable in terms of accurate correction of the two deformities, strut changes, and strut adjustments. The TL-HEX frame software was superior to other frames in terms of analyzing the deformity but the difference, although statistically significant clinically, was not.[8]

A Biomechanical Comparison between Taylor's Spatial Frame and Ilizarov External Fixator:

Tan et al Have conducted study to compare the mechanical properties of both frames using differing configuration for each frame design they applied forces on the frames using an Instron 3365 (MA, USA)

And they found that Standard TSF with 6 oblique struts fixed on to bone model can provide comparable stiffness on axial loading and better stiffness on torsional loading to conventional IEF with 4 threaded rods. The mechanical properties are theoretically favorable for both fracture healing and new bone formation. Changing to stronger hollow connecting bars or increasing the number of threaded rods did not significantly increase the stability against torsional forces. their findings suggest that TSF may provide a better alternative to conventional IEF as far as mechanical property is concerned.[9]

Comparison Of The Mechanical Properties Of The Tl-Hex And Frames:

Aim:

To investigate the biomechanical behaviours of the TL-Hex & Taylor Spatial Frame (TSF) Hexapod external fixators, with comparison to traditional ring-fixator constructs.

Methods:

Standardised four-ring TL-Hex and TSF constructs, as well as matched ilizarov threaded-rod constructs for each set of components, were tested alone and mounted with an acrylic bone model with simulated fracture gap using fine-wires. Loaddeformation properties for each construct and mode of loading were calculated and analysed statistically using ANOVA(also called analysis of variance which is a powerful statistical test used in this study).

Conclusions:

both hexapod designs were less rigid axially, but more so under bending and torsional loads, than their Ilizarov construct counterparts, producing greater overall planar shear strain, largely due to the observed "toe-in" laxity. Overall, the TL-Hex was seen to be more rigid than the TSF under bending loads although the difference in shear strain at the fracture site was not significantly different.[10]

References:

1- Wikipedia contributors. (2023, December 29). Ilizarov apparatus. Wikipedia, The Free Encyclopedia. https://en.wikipedia.org/w/index.php?title=Ilizarov_apparatus&oldid=1192491964

2- The history of Circular Frames - limbrecon.uk. (2021, June 18). Limbrecon.uk. https://limbrecon.uk/the-history-of-circular-frames/

3- Paley, Dror; Kovelman, Harry F; Herzenberg, John E (October 1993). "Ilizarov technology". In Stauffer, Richard (ed.). Advances in Operative Orthopaedics: Volume 1 (PDF). Mosby Inc. pp. 243-287.

4- Kenan Basha, Ahmad Alawadhi, Maha Alyammahi, Comparison of Three Circular Frames in Lower Limb Deformity Correction: A Biomechanical Study, Cureus. 2022 May; 14(5): e25271. https://doi.org/10.7759/cureus.25271

5- HEX-Ray [Internet]. Orthofix. 2022 [cited 2023 Nov 20]. Available from: https://orthofix.com/products/spine-solutions/digital-healthcare/hex-ray/

6- Eidelman, M; Katzman, A. (October 2008). "Treatment of complex tibial fractures in children with the taylor spatial frame". Orthopedics. 31 (10). PMID 19226013 https://doi.org/10.3928/01477447-20110525-17

7- Atif M, Mohib Y, Hasan O, Rashid H. In the cost-conscious era: Ilizarov circular frame or uniplanar external fixator for management of complex open tibia shaft fracture, retrospective cohort study from a level-1 trauma center. J Pak Med Assoc. 2020 Feb;70(Suppl 1)(2):S20-S23.

8- Basha K, Alawadhi A, Alyammahi M, et al, Comparison of Three Circular Frames in Lower Limb Deformity Correction: A Biomechanical Study, Cureus. 2022 May; 14(5): e25271. https://doi.org/10.7759/cureus.25271

Document Type : Review Article: Doi: https://doi.org/10.33762/bsurg.2024.144863.1064

9- Bb tan, R Shanmugam, R Gunalan, A Biomechanical Comparison between Taylor's Spatial Frame and Ilizarov External Fixator, Malays Orthop J. 2014 Jul; 8(2): 35-39 https://doi.org/10.5704/MOJ.1407.012

10- Fenton C, Henderson D, Cherkashin A, Samchukov M, Sharma HK. COMPARISON OF THE MECHANICAL PROPERTIES OF THE TL-HEX AND TSF FRAMES. Orthop Procs. 2018;100-B(SUPP_8):22-22.

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Work concept and design 1,2,3
Data collection and analysis 1
Responsibility for statistical analysis 1,2,3
Writing the article 1,2,3
Critical review, 1, 2
Final approval of the article 1,2,3
Each author believes that the manuscript represents honest work and certifies that the article is original, is not under consideration by any other journal, and has not been previously published.
Availability of Data and Material: The corresponding author is prompt to supply datasets generated during and/or analyzed during the current study on wise request.

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