Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies

Journal home page:www.jamdsr.com doi:10.21276/jamdsr Index Copernicus value [ICV] =82.06

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

Optimizing Diaphyseal Fracture Treatment: Dynamic Compression Plate Management for Radius and Ulna Fractures

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ABSTRACT:

Background: A significant decline in function may occur as a consequence of fractures in the forearm bones unless they are effectively treated, even if the fractures heal adequately. This study aims to examine the principles of dynamic compression plates, evaluate the functional outcomes of patients concerning the rate of fracture union and its complications, and investigate the follow-up process and restoration of forearm function. **Methods**: At our center, 40 patients with diaphyseal fractures of the radius and ulna underwent treatment using open reduction and internal fixation employing a dynamic compression plate and screws. The newly introduced AO compression plating apparatus appeared to fulfill the fundamental goals of internal fixation, including (1) achieving anatomical reduction, (2) preserving vascularity, (3) providing mechanically stable fixation, and (4) facilitating swift joint mobilization. The use of the 3.5 mm dynamic compression plate yielded outstanding outcomes, particularly in cases of forearm bone fractures, effectively reducing the risk of refracture. **Results**: Results of the treatment were notably favorable, with excellent outcomes observed in 60% of the cases, good results in 30%, and fair results in 10%. **Conclusion**: In conclusion, the dynamic compression plate proves to be an excellent choice for stabilizing displaced diaphyseal fractures of forearm bones. The provision of stable and rigid internal fixation eliminates the necessity for external immobilization in cooperative patients.

Keywords: Mechanical, fracture, compression plate

Received: 12-01- 2019 Accepted: 17-02-2019

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This article may be cited as: Kumar S. Optimizing Diaphyseal Fracture Treatment: Dynamic Compression Plate Management for Radius and Ulna Fractures. J Adv Med Dent Scie Res 2019;7(3):251-258.

INTRODUCTION

The intricate functionality of the forearm, intimately coordinated by the proximal and distal radioulnar joints, extends beyond the mere execution of essential pronation and supination movements[1]. Its role is far-reaching, encompassing a fundamental contribution to the intricacies of our daily activities. Through its dynamic capacity to position the hand in space, the forearm emerges as a pivotal player in conferring the distinctive and versatile mobility characteristic of the upper extremity.In the context of fractures affecting the radius and ulna shafts, the imperative lies in the nuanced and decisive management required for the effective restoration of function. The initial handling of diaphyseal fractures of the radius and ulna stands as a critical juncture, wielding substantial influence over the prevention of subsequent chronic and debilitating disorders that may afflict the forearm.The Monteggia fracture, eternally associated with the name of its describer, Monteggia, in 1814, unfolds as a clinical scenario marked by the fracture of the ulna shaft coupled with the consequential dislocation of the radial head. Conversely, the nightstick fracture, delineating a solitary ulna fracture without concurrent radial head dislocation, draws attention to a distinct injury mechanism, reminiscent of the unmistakable motion of a nightstick.In yet another manifestation, a single-bone fracture of the radius in its distal third, coupled with the intricate challenge of radioulnar joint dislocation, has acquired several eponyms[2]. Galeazzi's fracture, a designation attributed to Galeazzi in 1934, stands as a testament to the complexity of this injury, acknowledging its intricate nature and the ongoing challenges in its clinical understanding and management.Fractures of the forearm bones constitute more than a disruption of skeletal continuity; they represent a significant challenge to the intricate balance required for the normal functioning of the

upper limb. The forearm's biomechanical intricacy, involving the radius and ulna, is vital for executing a myriad of movements crucial to our daily lives—ranging from the precise manipulation of objects to the coordination needed for tasks as fundamental as turning a doorknob.

In the aftermath of such fractures, a cascade of consequences unfolds, threatening not only the structural integrity of the bones but also the seamless orchestration of movements. Failure to intervene promptly and effectively in the face of these fractures can lead to dire functional repercussions. The potential for a severe loss of function looms large, casting a shadow over routine activities and compromising the fluidity of motions essential to a fully functioning limb.It is noteworthy that even with fractures healing in a manner deemed medically satisfactory, a disconnect may persist between structural recovery and the restoration of optimal function. This disjunction underscores the imperative of a nuanced treatment methodology that extends beyond the conventional focus on fracture reduction and stabilization.In essence, a multifaceted treatment approach is essential. It should not only address the biomechanical aspects of bone healing but also encompass comprehensive rehabilitation strategies. This involves physiotherapy aimed at restoring strength, flexibility, and proprioception, as well as considerations for ergonomic adjustments tailored to the patient's specific needs. The overarching goal is to not merely mend fractured bones but to usher in a holistic recovery that encompasses both structural soundness and the restoration of a full spectrum of functional capabilities.In navigating the complex terrain of forearm fractures, the emphasis on a tailored, patient-centric approach becomes pivotal. By integrating cutting-edge medical interventions with a holistic rehabilitation perspective, we not only heal bones but also empower individuals to reclaim the optimal range of motion, stability, and function in their forearms.

MATERIALS AND METHODS

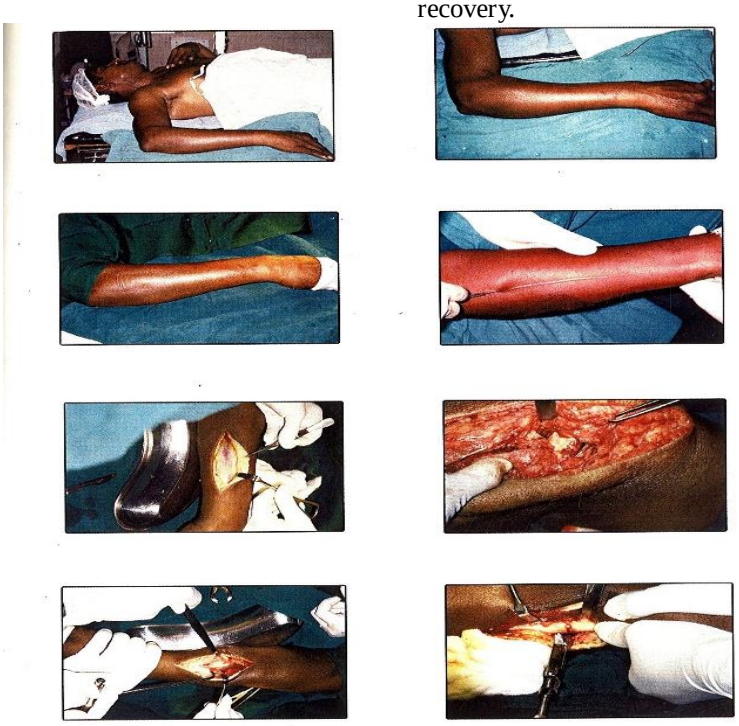
This study involved a cohort of 40 patients diagnosed with forearm fractures. The selected treatment approach for these cases comprised open reduction and internal fixation utilizing a dynamic compression plate (DCP) along with screws. This method was specifically applied to patients presenting with displaced fractures of the forearm bone shafts. The study focused on individuals who not only underwent the prescribed treatment but also actively participated in regular follow-up clinics, collectively constituting the substantive material for analysis and observation. The emphasis on open reduction and internal fixation with DCP and screws underscores the importance of stabilizing and aligning the fractured bones for optimal healing, and the commitment to regular follow-up appointments suggests a comprehensive evaluation of the long-term outcomes and recovery progress for these patients. The study, thus, aims to contribute valuable insights into the efficacy and sustained benefits of this particular therapeutic approach for forearm fractures.In the realm of orthopedic research, the meticulous design of inclusion and exclusion criteria holds paramount importance to ensure the precision and relevance of the study outcomes. In this particular investigation, the inclusion criteria have been strategically crafted to delineate a cohort that encapsulates the nuances of forearm fractures while introducing diversity to enrich the findings.

The inclusion of patients with diaphyseal fractures of the radius and ulna is foundational, aligning with the study's primary focus on this specific anatomical region. The consideration of isolated fractures of either the radius or ulna acknowledges the distinct characteristics and potential treatment intricacies associated with each bone[3]. Moreover, the inclusion of Type I and Type II compound fractures introduces a graded spectrum of severity, acknowledging the heterogeneous nature of forearm injuries.The inclusion of both genders ensures a comprehensive exploration of forearm fractures, recognizing that these injuries can affect individuals regardless of gender. The specified age range, delineated between 14 and 60 years, not only reflects a demographic where forearm fractures are more prevalent but also allows for a more cohesive analysis of fracture dynamics and healing processes within this specific age group.Extending the inclusion criteria to patients with fractures in both upper limbs broadens the study's scope to assess bilateral impacts, if any, on treatment outcomes. The inclusion of Monteggia and Galeazzi fractures, with their unique complexities, adds an additional layer of diversity, providing an opportunity to scrutinize treatment responses in the context of these distinctive fracture patterns.Conversely, the exclusion criteria serve to refine and streamline the study population. The exclusion of individuals above the age of 60 acknowledges potential variations in fracture responses related to age-related factors such as bone density and healing capacity. Excluding patients with associated neurovascular injuries ensures a focused analysis on fractures, disentangling the impact of nerve or blood vessel damage from the primary fracture considerations.The exclusion of pathological fractures maintains the study's fidelity to traumatic etiologies, offering insights specifically relevant to fractures resulting from external forces. The exclusion of Type III open fractures standardizes the severity level, enabling a more controlled investigation into the defined criteria.In essence, these meticulously crafted inclusion and exclusion criteria serve as the bedrock of the study, fortifying its scientific rigor and positioning it to contribute valuable and nuanced insights into the treatment and outcomes of forearm fractures. By embracing diversity within defined parameters, the study aspires to offer a comprehensive

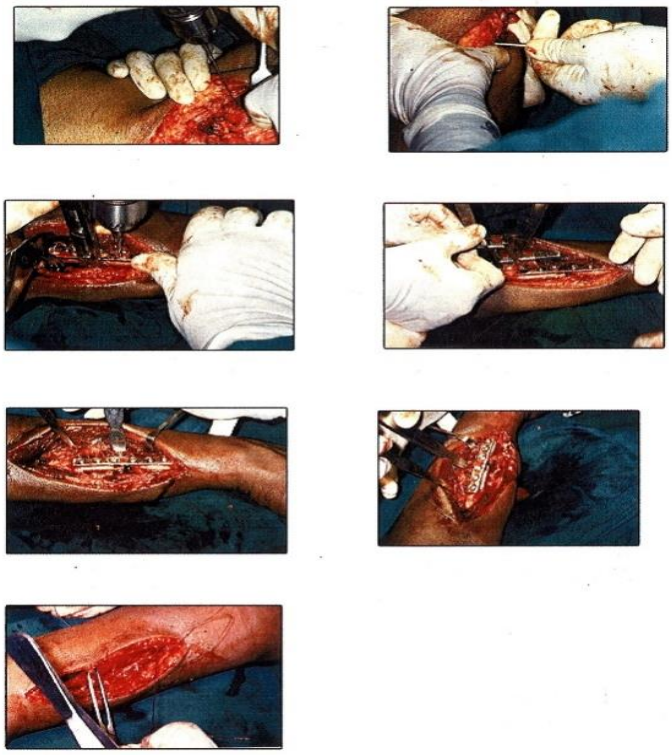
understanding of this complex orthopedic domain.In this patient cohort, comprising 28 male and 12 female participants, the average age of the study population was determined to be 37 years. This demographic distribution reflects a gender-wise representation, recognizing potential variations in the prevalence and characteristics of forearm fractures between males and females.Within the identified cases, seven instances presented with fractures involving both bones of the forearm, underscoring the study's inclusivity towards more complex injury patterns[4]. Additionally, eight cases were characterized by an isolated fracture of the radius shaft, emphasizing the significance of understanding and managing fractures in specific anatomical regions. Similarly, four cases demonstrated an isolated fracture of the ulna shaft, further enriching the spectrum of forearm injuries considered in this study.It's noteworthy that the criteria proposed by F.M. Marek et al. in 1961 were employed as the guiding framework for patient selection and classification. This suggests a meticulous approach, aligning the study with established criteria to enhance comparability and consistency in assessing and categorizing forearm fractures.The demographical breakdown, combined with the diverse fracture presentations and the application of well-defined criteria, establishes a solid foundation for this study. By incorporating both gender representation and a range of fracture types, the research aims to provide a nuanced exploration of forearm fractures, potentially yielding valuable insights into their characteristics, management, and outcomes.

RESULTS

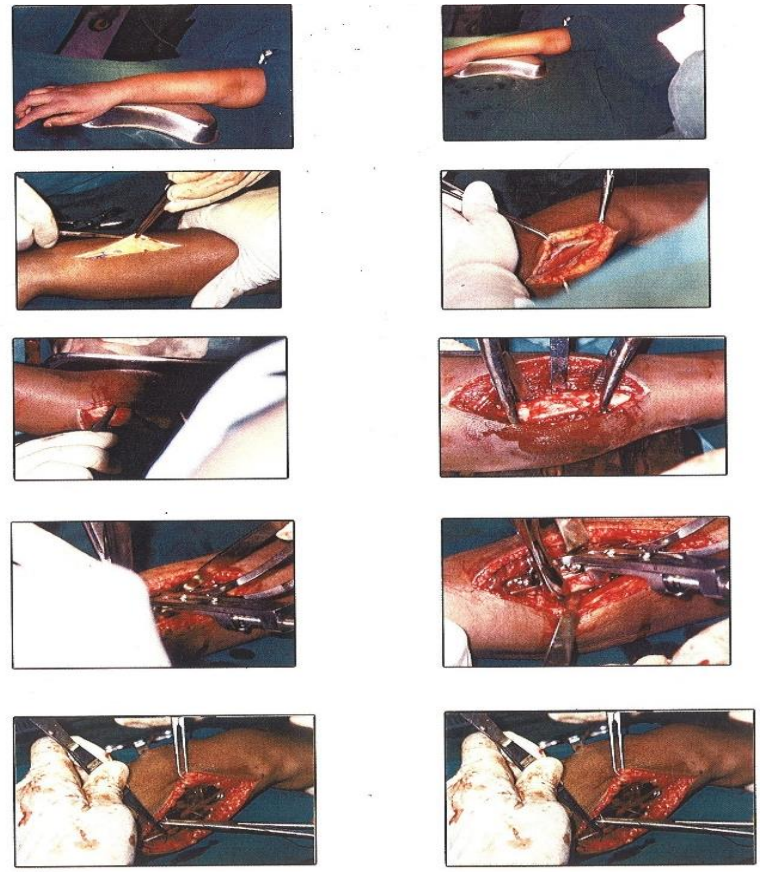
In the course of our study, a rigorous and regular follow-up protocol was implemented, with all patients undergoing assessment every month. This structured follow-up involved posing specific questions to the patients, and their responses were then subjectively evaluated. Our primary objective was to establish a correlation between the subjective health status reported by the patients and the objective and radiological outcomes following open reduction and internal fixation for fractures involving both bones of the forearm[5].To comprehensively gauge the post-treatment status, various objective measures were employed. The range of movement of the forearm and wrist, grip strength, and pinch strength were quantitatively measured. These objective assessments provided a standardized and quantifiable basis for evaluating the functional aspects of the treated forearms.In addition to these functional metrics, the study incorporated radiological evaluations using standardized radiographs. This allowed for an in-depth examination of the structural outcomes following operative stabilization of fractures in both the radius and ulna. By combining subjective, objective, and radiological assessments, our study sought to provide a holistic understanding of the treatment outcomes and overall functional well-being of patients who underwent open reduction and internal fixation for forearm fractures. The findings of our study indicate that the operative stabilization of fractures in both the radius and ulna consistently resulted in a functionally acceptable outcome. This suggests the effectiveness and reliability of the chosen treatment approach in not only achieving structural integrity but also in promoting satisfactory functional recovery.



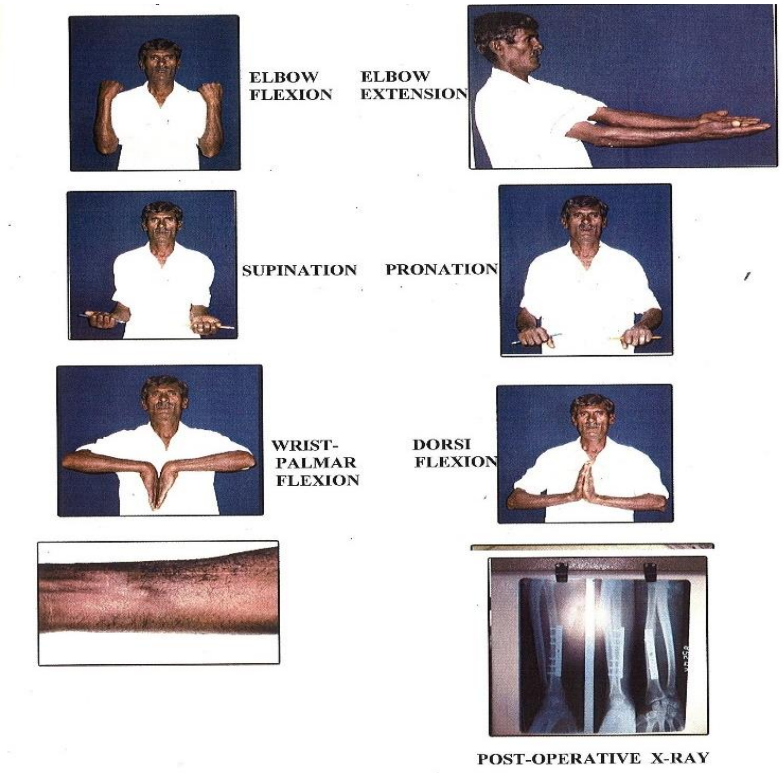
STEPS OF DYNAMIC COMPRESSION PLATE APPLICATION-FRACTURE MIDDLE 1/3RD SHAFT OF THE RIGHT ULNA



**STEPS OF DYNAMIC COMPRESSION PLATE APPLICATION-
FRACTURE MIDDLE 1/3RD SHAFT OF THE RIGHT ULNA (continued)**

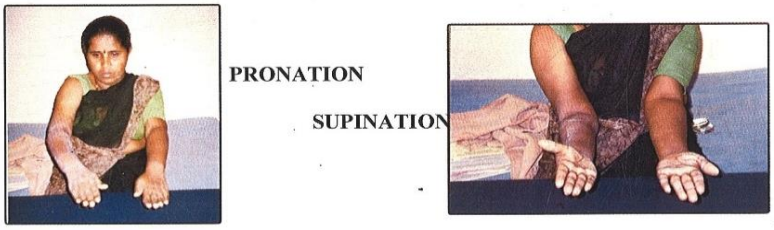


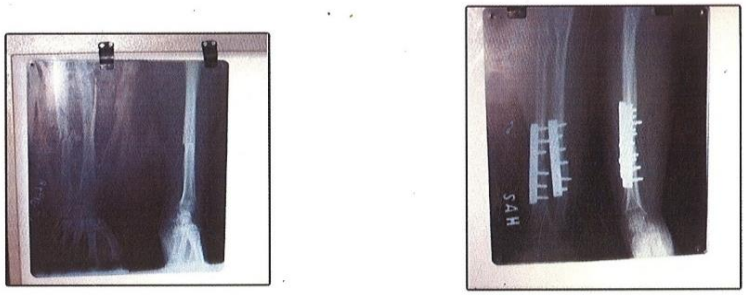
**STEPS OF DYNAMIC COMPRESSION PLATE APPLICATION–
FRACTURE BOTH BONES MIDDLE 1/3RD Rt-FOREARM**



POST-OPERATIVE X-RAY

FOLLOW UP
(SIMPLE FRACTURE MIDDLE 1/3RD Rt-RADIUS)





PRE-OPERATIVE AND POST OPERATIVE X-RAYS

FOLLOW UP (SIMPLE FRACTURE MIDDLE 1/3RD BOTH BONES Rt-FOREARM)

The integration of subjective patient-reported data, along with objective and radiological assessments, enhances the robustness and comprehensiveness of our study, contributing valuable insights to the field of forearm fracture management.In our research, the collected data underwent a meticulous analysis by comparing it with both the preoperative and immediate postoperative records. The primary focus was on evaluating the union of fractures, gauged by criteria outlined by Muller et al. in 1950. The

assessment criteria encompassed the obliteration of the fracture line and the bridging of trabeculae, providing a standardized and well-established foundation for the evaluation process.The specific cohort under investigation involved twenty cases of forearm fractures, and these were managed through open reduction and internal fixation utilizing Dynamic Compression Plate and screws. The study embraced a diverse demographic, encompassing various age groups and both sexes. A detailed analysis and evaluation of the results were then conducted based on the accumulated data.In the context of patient demographics, our study included individuals within the age range of above 14 and below 60 years. This deliberate age range was chosen to provide a focused exploration of forearm fractures within a specific demographic where these injuries are likely more prevalent.The study cohort comprised twenty patients diagnosed with closed diaphyseal fractures of one or both forearm bones. Among these individuals, there were 28 males and 32 females, with ages spanning from 15 to 60 years. This gender-inclusive approach contributes to a comprehensive understanding of how forearm fractures may manifest and be managed across diverse populations.The distribution of fracture types within our study cohort highlighted the variability of presentations. 12 patients exhibited both bone fractures, eight had an isolated fracture shaft of the radius, five presented with an isolated fracture shaft of the ulna, and one patient had a Monteggia fracture dislocation[6]. This diverse range of fracture patterns not only adds complexity to the study but also offers insights into the versatility and efficacy of the chosen treatment approach across different scenarios.In summary, our study's robust methodology, inclusive patient demographics, and comprehensive evaluation criteria contribute to a nuanced exploration of the outcomes following open reduction and internal fixation for forearm fractures. The amalgamation of age, gender, and fracture type diversity enriches the study's potential to provide valuable insights into the management and recovery of individuals with forearm injuries.In our study, all patients presented with common symptoms of forearm fractures, including pain, deformity, and loss of function in the affected area. To address these fractures, we employed separate incisions for the radius and ulna, tailoring our approach based on the specific nature and location of the fractures. The choice of incisions included Thompson's approach for the upper half of radial fractures, anterior Henry's approach for the lower half of radial fractures, and Galeazzi fracture dislocations. Ulnar fractures were exposed through a direct approach along the subcutaneous border of the ulna, between the olecranon and the ulnar styloid process.A seven-holed 3.5 mm Dynamic Compression Plate (DCP) was commonly utilized in most cases for internal fixation. Postoperative cast protection was administered for two weeks, primarily for patients who exhibited non-compliance with the prescribed treatment plan. The follow-up period for patients in our study ranged from six to twelve months, with some individuals deferring their follow-up appointments. Radiological assessments consistently revealed satisfactory union of the fractures in all cases.The discussion surrounding our study emphasizes the pivotal role of the forearm in upper extremity function, highlighting its contribution to hand positioning and overall upper limb mobility. The intricate biomechanics involving the proximal and distal radioulnar joints, facilitating pronation and supination, further underscores the functional significance of the forearm in daily activities.Managing fractures of the radius and ulna shafts requires exacting and decisive measures for optimal restoration of function. The study acknowledges the potential for chronically disabling disorders in the forearm if initial management of diaphyseal fractures is not competent. Closed reduction of displaced fractures is challenging and maintaining it proves difficult, leading to reported unsatisfactory results ranging from 36% to 75%[7]. Consequently, open reduction with internal fixation is considered routine, especially for displaced fractures.The treatment approach involves open reduction, plate fixation, and cancellous bone grafting for fractures involving both bones or displaced isolated fractures, particularly when there is bone loss. This semi-elective procedure is performed as soon as the patient's condition allows, preferably within the first 48 hours for optimal reduction. The use of seven-holed 3.5 mm plate systems has notably reduced the incidence of refracture after plate removal.Cancellous bone grafting, in addition to plate fixation, is recommended, given the nearly 100% union rate achieved with this combined method. Following the procedure, forearm immobilization in a long-arm plaster cast is implemented until radiographic evidence of union is observed. For compliant patients, a transition to a removable splint is considered, and early motion is initiated as soon as wound healing is complete.The study aligns with the principles formulated by the AO to improve fracture treatment outcomes, emphasizing the importance of internal fixation in achieving stable and reliable results. Overall, our study contributes insights into the effective management of forearm fractures, addressing both the structural and functional aspects of patient recovery.

DISCUSSION

The AO's groundbreaking principles of fracture management, articulated in 1984 by Müller and colleagues, have significantly influenced the landscape of orthopedic surgery. Anatomical reduction, the initial principle, stands as a foundational pillar emphasizing the meticulous realignment of fractured bone components. This meticulous approach seeks to restore the natural anatomy of the injured bone, mitigating the risk of

long-term complications such as malunion and optimizing the conditions for effective healing.The second principle, stable internal fixation, introduces the crucial concept of utilizing implants like plates, screws, or nails to secure fractured bone fragments in a stable position. By providing biomechanical stability, this principle not only facilitates early mobilization but also plays a pivotal role in preventing displacement and promoting the successful fusion of fractured bones. The choice of appropriate implants and their precise application becomes paramount, reflecting the nuanced understanding required in implementing stable internal fixation.Preservation of blood supply, the third principle, underscores the intricate relationship between vascular integrity and successful fracture healing. Surgeons are encouraged to handle tissues delicately during procedures, minimizing damage to blood vessels[8]. Additionally, efforts are made to preserve the periosteum, recognizing its crucial role in the nourishment of bone and the facilitation of optimal healing conditions.Completing the quartet, the principle of early, active mobilization represents a departure from traditional notions of prolonged immobilization. Instead, it advocates for a proactive approach to controlled movement of the affected limb soon after treatment. This shift aims to counteract complications associated with prolonged immobility, including joint stiffness and muscle atrophy. Furthermore, early mobilization is tailored to specific fracture types, the stability of fixation, and individual patient considerations, reflecting a personalized approach to rehabilitation.Together, these principles encapsulate a holistic framework for fracture management, harmonizing the biomechanical intricacies of stable internal fixation with the biological imperatives of anatomical alignment, preservation of blood supply, and early mobilization. By combining these principles, orthopedic surgeons adhere to a comprehensive and evidence-based strategy, ultimately advancing the field and improving patient outcomes in the realm of fracture treatment.Müller et al.'s criteria for assessing fracture healing represent a cornerstone in the orthopedic field, offering a comprehensive framework that extends beyond radiographic images to encompass both structural and functional aspects of bone recovery. The concept of fracture line obliteration, as outlined by these criteria, encapsulates the successful reintegration of fractured bone segments into a cohesive unit. This visual verification, gleaned from meticulous examination of imaging studies, is pivotal in confirming that the once-disrupted bone has undergone a transformative healing process, marked by the absence of a discernible fracture line.Delving deeper into the significance of trabecular bridging, this element of Müller et al.'s[9] criteria acknowledges the dynamic and biological intricacies of bone healing. Trabeculae are not mere structural components but essential contributors to bone strength and resilience. The observation of trabecular bridging across the fracture site signifies more than structural integrity; it represents the ongoing regeneration and remodeling of bone tissue. This dynamic process is crucial for restoring not only the bone's form but also its internal architecture and function.In practical terms, the application of these criteria involves a longitudinal approach to monitoring the healing trajectory. Regular radiographic assessments provide a visual timeline, allowing clinicians to gauge the progression of fracture healing over time. The criteria's dual emphasis on both structural confirmation and biological markers ensures a holistic evaluation that goes beyond a simple "yes" or "no" determination. This nuanced approach allows healthcare professionals to tailor their interventions based on the evolving needs of each patient.Furthermore, Müller et al.'s criteria have influenced not only clinical practice but also research methodologies, providing a standardized language for describing and categorizing fracture healing outcomes. The criteria offer a common ground for communication among healthcare professionals, facilitating interdisciplinary collaboration and enhancing the comparability of research findings across different studies.Ultimately, Müller et al.'s criteria for fracture evaluation have contributed to a paradigm shift in the understanding of fracture healing. Moving beyond a binary assessment, they embrace the complexity of the healing process, acknowledging the interplay between structure and function. As orthopedic care continues to evolve, these criteria remain a foundational guide, ensuring that the evaluation of fracture healing remains nuanced, thorough, and patient-centered.The dynamic compression plate (DCP) represents a significant advancement in the field of orthopedic surgery, particularly in the management of fractures demanding stable fixation. Crafted with precision from durable materials like stainless steel or titanium, the DCP's anatomically contoured design ensures a seamless fit to the surface of the fractured bone. Its distinctive feature lies in the arrangement of multiple holes along its length, strategically positioned to allow for the precise insertion of screws.

The dynamic compression mechanism is a hallmark characteristic of the DCP. As surgeons meticulously affix the plate to the fractured bone using screws, the controlled tightening of these screws results in dynamic compression at the fracture site. This process is pivotal in achieving interfragmentary compression, where the bone fragments are brought into close contact[10]. This compression not only minimizes micro-movements at the fracture site but also enhances the biological conditions necessary for optimal bone healing.The application of DCP is particularly relevant in long bone fractures, such as those occurring in the femur or humerus, where stability is paramount for successful recovery. The plate's ability to generate dynamic compression is

especially beneficial in mitigating the risk of delayed union or nonunion by promoting a biomechanically favorable environment for bone consolidation.While the surgical application of a DCP may necessitate a larger incision and, in some cases, soft tissue dissection, the advantages it offers in terms of stability and compression outweigh these considerations. The rigid stabilization provided by the DCP allows for early mobilization and rehabilitation, contributing to improved patient outcomes and reducing the risk of complications associated with prolonged immobility.

As orthopedic technology continues to evolve, the DCP remains a vital component in the armamentarium of fracture fixation methods. Its versatility, coupled with the ability to dynamically compress fracture sites, makes it a preferred choice for orthopedic surgeons seeking reliable solutions in the pursuit of optimal bone healing and functional recovery for their patients. In summary, the dynamic compression plate stands as a testament to the intersection of biomechanics and biology in the quest for advancing fracture care.

CONCLUSION

In conclusion, the dynamic compression plate emerges as a highly effective option for addressing displaced diaphyseal fractures of forearm bones. Its design and functionality, featuring an anatomically contoured plate with multiple screw holes, allow for precise and stable internal fixation. This quality is particularly advantageous in providing the necessary support for fractured bones, eliminating the requirement for external immobilization in cooperative patients.The dynamic compression plate's ability to generate controlled compression at the fracture site plays a pivotal role in promoting optimal healing conditions. By bringing fractured bone fragments into close contact, the plate facilitates interfragmentary compression, reducing the risk of complications associated with delayed union or nonunion. This not only accelerates the healing process but also enables early mobilization and rehabilitation, contributing to improved patient outcomes.Furthermore, the avoidance of external immobilization in cooperative patients offers several benefits, including enhanced patient comfort and a reduced risk of complications related to prolonged immobilization. The rigid stabilization provided by the dynamic compression plate allows for a quicker return to functional activities, ultimately improving the overall quality of life for individuals undergoing forearm fracture treatment.In orthopedic practice, the dynamic compression plate stands out as a versatile and reliable tool, particularly well-suited for fractures in the forearm's diaphyseal region. Its incorporation into treatment plans reflects a commitment to providing stable internal fixation, ensuring both biomechanical integrity and favorable biological conditions for the fractured bones. As the field continues to advance, the dynamic compression plate remains a cornerstone in the pursuit of optimal fracture care, offering a valuable solution for orthopedic surgeons and their patients alike.

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