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Pediatric Orthopedics

Reply to the Letter to the Editor Regarding “Description of Hip Deformities in 5-Year-Old Patients with Congenital Zika Virus Syndrome: A Cross-Sectional Study”

Herison Franklin Viana de Oliveira, Francisco Robson Queiroz Rego, Brauner de Souza Cavalcanti, Ítalo Rodrigues Bacellar, Thais Araújo Barbosa, Epitácio Leite Rolim Filho

Description of Hip Deformities in 5-Year-Old Patients with Congenital Zika Virus Syndrome

Amnuay Kleebayoon, Viroj Wiwanitkit

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Updates on Bone Grafts and Substitutes

Atualizações em enxertos e substitutos ósseos

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Abstract

Bone defects caused by trauma, infections, neoplasms, and other conditions are commonly treated with autologous grafts, which are considered the gold standard due to their osteoinduction, osteoconduction, and osteogenesis properties. However, their use has limitations, including limited availability, donor-site morbidity, and increased surgical time. Alternatively, allogeneic grafts, xenografts, and synthetic bone substitutes, including ceramics, bioglasses, resins, and metals, have been developed and are often modified with osteoinductive elements, such as growth factors and bioinorganic ions. The ideal bone replacement should be biocompatible, bioabsorbable, mechanically resistant, porous, and capable of promoting osseointegration. Although synthetic substitutes have advanced, they have not yet achieved the effectiveness of autologous grafts, especially concerning osteointegration and economic viability. However, innovations in molecular biology, bone proteins, and gene therapies offer promising prospects for the development of new biomaterials. The current article introduces the reader to bone substitutes by presenting a classification of the materials used and the main characteristics of each group.

Keywords
- bone cements
- bone regeneration
- bone remodeling
- bone substitutes

Resumo

Os defeitos ósseos, causados por traumatismos, infecções, neoplasias e outras condições, são comumente tratados com enxerto autólogo, que é considerado o padrão-ouro devido às suas propriedades de osteoindução, osteocondução e osteogênese. No entanto, seu uso apresenta limitações, como a disponibilidade restrita, a morbidade no local doador e o aumento do tempo cirúrgico. Como alternativas, enxertos alógenos, xenógenos e substitutos ósseos sintéticos, que incluem cerâmicas, biovidros, resinas e metais, têm sido desenvolvidos, sendo frequentemente modificados com o acréscimo de elementos osteoindutores, como fatores de crescimento e íons bioinorgânicos. O substituto ósseo ideal deve ser biocompatível, bioabsorvível,

Palavras-chave
- cimentos ósseos
- regeneração óssea
- remodelação óssea
- substitutos ósseos

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mecanicamente resistente, poroso e capaz de promover osteointegração. Embora os substitutos sintéticos tenham avançado, ainda não alcançaram a eficácia do enxerto autólogo, principalmente no que se refere à osteointegração e à viabilidade econômica. Contudo, as inovações em biologia molecular, proteínas ósseas e terapias genéticas oferecem perspectivas promissoras para o desenvolvimento de novos biomateriais. Este artigo pretende apresentar ao leitor o tema dos substitutos ósseos, com uma classificação dos grupos de materiais utilizados e as principais características de cada grupo.

Introduction

Bone defects are a clinical condition faced by orthopedists, neurosurgeons, head and neck surgeons, as well as dentists. In the orthopedic practice, these defects can result from high-energy trauma and major bone resections due to different pathologies, such as tumors, infections, loosening of prostheses, or complications in bone consolidation. The filling of bone defects aims to restore bone structure and, especially, mechanical strength.[1,2] The alternatives available for this filling can be grouped into grafts (biological materials) and substitutes (synthetic materials).[2]

Autologous cancellous bone graft is recognized as the gold standard to treat bone defects or augment bone tissue. Each year worldwide, more than two million orthopedic surgeries are performed in which bone grafts are harvested, making it the second most common type of transplant, only behind blood transfusion.[2] Autologous bone is considered the ideal graft, as it is completely compatible and has all the indispensable characteristics for the osteointegration process, including osteoinduction, osteoconduction, and osteogenesis.[1,3] However, limited graft availability, potential donor-site morbidity, and the increased surgical time require the search for alternatives. [2,4]

In bone defects, several types of biomaterials are being developed and tested, involving collaboration across areas such as medicine, biology, chemistry, engineering, and dentistry.[4,5]

The goals of the current article are to present treatment alternatives for bone defects and their classification, and to discuss the theoretical principles of integrating bone substitutes and the future trends in the development of biomaterials.

Definitions

Broadly speaking, grafts can be considered bone substitutes, as they meet the criteria for biomaterials. However, this term is most often used to describe synthetic materials derived from elements found in nature, and they can be classified into ceramics, polymers, bioglasses, and metals.[6] Therefore, *biomaterials* are natural or synthetic materials intended to replicate the form and/or function of different human or animal tissues, and they can act permanently or transiently.[7] Bone substitutes can be used to fill defects, replace bone segments, and to reinforce and stimulate bone consolidation at various body sites, percutaneously or openly. They should be structurally similar to bone, mechanically resistant, easy to handle, safe, and affordable.[8]

Some features of bone substitutes are extremely important. They must present *biocompatibility* or at least biotolerance to ensure proper assimilation into biological tissues. *Biocompatibility* means that the organism accepts the material naturally, interacting with it at the metabolic level, while biotolerance indicates that it is accepted by the organism without causing significant adverse reactions, even if it does not elicit an ideal response.[3]

Osseointegration is the main expected property of a bone substitute, characterized as the process of interdigitation between the host bone tissue and the implant. In this process, the recipient bone forms new bone tissue that penetrates the microscopic irregularities of the surrogate's surface, thereby stabilizing and fixing it in the insertion region.[1,8] This biological and mechanical integration is crucial to the implant's functionality and longevity.[2,6]

Osteointegration depends on the following processes: osteogenesis, osteoconduction, and osteoinduction. *Osteogenesis* is the ability of the substitute to promote the formation of new bone tissue;[3] in practice, only the autologous graft has this property. *Osteoconduction* is the structural property of the material serving as physical support for the growth and regeneration of bone tissue. Osteoconductive material guides and facilitates the invasion and growth of bone cells, blood vessels, and bone matrix at sites where bone regeneration is occurring.[3] Such property is closely related to the material's surface characteristics and the dimensions of its pores, channels, or wells. *Osteoinduction* refers to a biomaterial's ability to stimulate undifferentiated cells to differentiate into osteoblasts, which are responsible for the formation of bone tissue[3], thus promoting osteogenesis.

Regarding the structure of the bone substitute, it is recommended that its morphology be analogous to that of the bone to be replaced, whether cortical or cancellous. However, integration depends on *pores* that enable invasion of newly-formed bone. For osteoblast invasion, pores between 80 µm and 200 µm are sufficient; for capillary invasion, pores between 300 µm and 500 µm are required, and this process will only be successful if the pores are

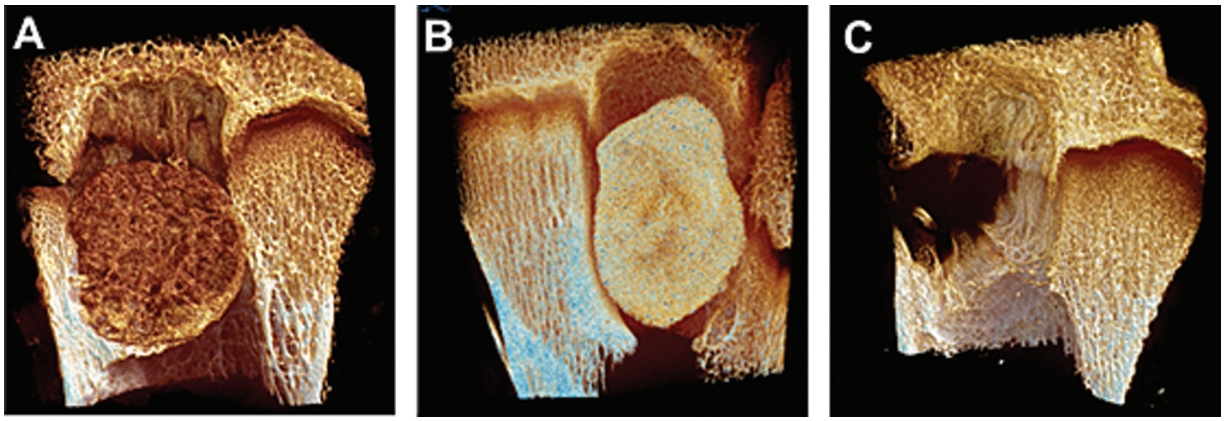


Fig. 1 Comparison involving bone failures filled with porous bone substitute (**A**), solid cement block (**B**), and without filling (**C**), 3 months after surgery in rams, analyzed by microtomography. In (**A**), the contact between the bone and the surrogate is intimate, which indicates osseointegration. In (**B**), receptor bone resorption around the cement block and formation of fibrous tissue occurs. In the unfilled defect (**C**), the development of neoformed bone spicules seeking to invade the defect is observed.

interconnected.[9–11] Porosity also has a direct influence on the mechanical characteristics of the biomaterial; the more porous it is, the higher the modulus of elasticity, and the lower its mechanical strength[12] (►**Figs. 1A–C**).

Two quantities are considered among the *mechanical characteristics* of the material: its strength, which is the load-bearing capacity of the material before fracture, and its elasticity, which is the ability of the material to deform temporarily under the load application and return to its original shape after removal of that load. Low resistance leads to fractures and mechanical failure of the implant. The discrepancy between the elasticities of the host bone and the implant, in turn, causes micromovements in the bone–biomaterial interface, preventing osseointegration.[11,12]

The ability of the organism *to absorb* the substitute is highly desirable because it enables the gradual replacement by newly-formed bone tissue.[2,13] To maintain mechanical strength, the rate of resorption must be compatible with the speed of formation of new bone. In addition, the resorption rate is influenced by the porosity of the bone substitute, as this determines the area of contact between the material and the surrounding biological tissue.[2,14]

The *presentation* of the substitute defines its best application. Moldable bone cements are best suited for filling misshapen spaces, while structured blocks are preferable in osteotomies. The *cost* and the amount of *material available* for the implant finalize the list of important properties of bone substitutes. The addition of growth hormones and the three-dimensional (3D) printing of metals such as tantalum increase the cost, while polymethylmethacrylate (PMMA) bone cement remains the most used in the clinical practice, mainly due to its low cost.

Types of grafts

The *autologous graft* (also called *autogenous graft* or *autograft*), taken from the patients themselves, is considered the ideal graft because it does not provoke an immunological reaction and exhibits osteoinduction, osteoconduction, and osteogenesis.[6] However, limited availability, potential morbidity of the donor site, additional surgery, increased operative time, increased blood loss, chronic pain in the donor region, dysesthesia, and infections impose limits on its use in the clinical practice.[1,2]

Cancellous autologous grafts are often obtained from the iliac bone, tibia, olecranon, and calcaneus, which are poor in osteoblasts and osteocytes but are rich in primitive mesenchymal cells and osteoinducive factors, which facilitate revascularization and incorporation into the receptor site.[6] Cortical autologous grafts are obtained from the fibula and rib.[1] As the cortical graft contains a limited number of osteoprogenitor cells, integration occurs via osteoclast-mediated resorption, followed by apposition of newly-formed bone on the necrotic scaffold of the transplanted bone. This process is slower than the integration of cancellous bone.[6] The corticocancellous graft of the iliac crest combines the ease of integration of the cancellous bone with the structural integrity of the cortical bone.[15] Some cortical grafts (from the fibula and rib) and corticocancellous grafts (from the iliac crest) can be transplanted as flaps or vascularized grafts requiring microdissection or anastomosis. Medullary canal reaming, associated with irrigation and aspiration (reamer-irrigator-aspirator, RIA), is a method to obtain a greater volume of autologous graft with higher levels of growth factors and stem cells.[16]

Biological alternatives to autologous grafts are *allogeneic grafts* (*homologous grafts* or *allografts*), which come from another individual of the same species, and *xenogeneic grafts* (*xenografts*), which come from another species.

Allogeneic grafts are available as bone segments and bone preparations. The segments are stored in tissue banks in various sizes and formats (total, cancellous, cortical), including for osteoarticular reconstructions.[17] Among the limitations of allografts are their lower incorporation capacity,

greater risk of failure, potential immunogenicity and disease transmission, and the need for chemical preparation and storage methods such as lyophilization, freezing, or irradiation, which can affect their mechanical properties.[1,6] The most common processed allograft is the demineralized bone matrix (DBM),[6] which preserves growth factors but is limited by its lack of mechanical resistance, and it is more commonly used in dentistry.[18]

Xenografts, which are derived from bovine, porcine, and equine bones, are processed to remove biological components and preserve hydroxyapatite (HA) and, occasionally, the collagen matrix. Their application in orthopedics has restrictions.[1,19] Extracted from other species, there is still chitosan, from shrimp shells, which is used to stimulate bone regeneration and cell differentiation, and HA extracted from corals.[2]

Types of bone substitutes

Bone substitutes can be technically grouped into four broad classes: ceramics, bioglasses, polymers, and metals.[15] *Ceramics* are widely used as bone substitutes due to their great biocompatibility. The great diversity in presentation creates some confusion regarding the nomenclature. The most commonly used material is calcium phosphate, which can be used in its crystalline form, which is found in animals (HA), or in the amorphous form, the most common example of which is beta-tricalcium phosphate (β-TCP). The combination of both is called *biphasic calcium phosphate* (BCP), and its presentation in cement form is known as *calcium phosphate cement* (CPC).

The main mineral component of bones and teeth, HA can be extracted from nature or synthetically produced in the form of particles or nanoparticles.[18] It has a low resorption rate, limited mechanical strength, and good osteoconductivity. That is why HA is widely used as an implant coating and less to fill bone defects. Notably, its nanocrystalline form demonstrates better biological performance, favoring cell adhesion and osteogenic differentiation.[20]

Tricalcium phosphate, which is characterized by its rhombohedral structure and a lower calcium/phosphate ratio than HA, resorbs more rapidly (13–20 weeks).[13] Its interconnected micropores facilitate osteogenic cell invasion and angiogenesis, but its limited mechanical stability restricts its application under high-load conditions.[21] Despite this, β-TCP is widely researched and commercially available.[1]

Biphasic calcium phosphate, a mixture of HA and β-TCP in varying proportions (40–60% of each), offers a balance between mechanical support and physiological bone resorption, making it a promising option for diverse clinical applications.[1,22]

Calcium phosphate cements are moldable during the filling of bone defects.[23] Formed by mixing liquid and powdered components that precipitate in HA nanocrystals, they present low mechanical strength and porosity, limiting reabsorption and invasion by new bone. They are injectable

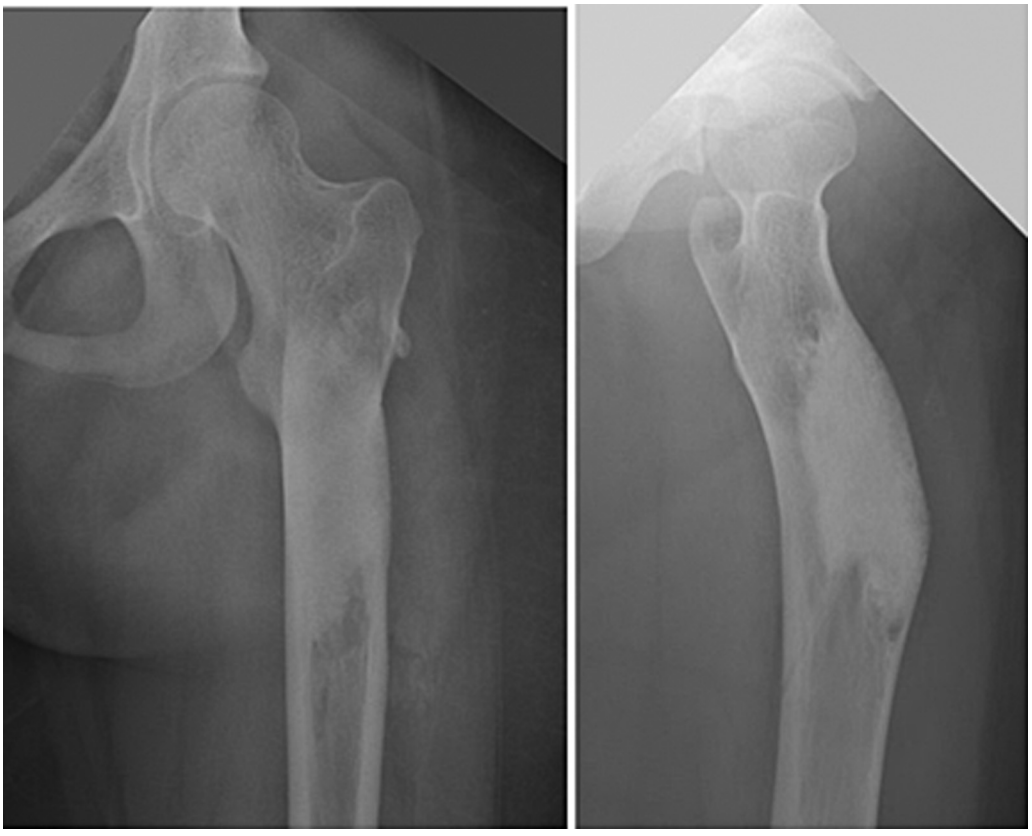


Fig. 2 Femur radiograph showing the integration of calcium phosphate cement implanted 2 years before.

and can carry biologically-active components such as osteoprogenitor cells and growth factors.[23] Due to their malleability, injectability, bioactivity, and biocompatibility, CPCs are a reality in the treatment of bone defects and highly promising for tissue engineering applications (►**Fig. 2**).

Calcium sulfate (plaster in its pure form) shows complete resorption in 6 to 8 weeks and weak stimulation of bone formation. To circumvent these restrictions, its application is often combined with DBM, which improves clinical outcomes.[1]

Bioglasses are ceramics with a high concentration of silicate (45–52%), which are glasses and exhibit bioactivity due to their ability to strongly bind to the host bone.[24] Their bioactivity is believed to result from silicon ion leaching into body fluids;[24] these ions promote the formation of a layer of HA on the surface of the bioglass, attracting osteoprogenitor cells and initiating the gradual replacement of the material by the newly-formed bone. The high porosity and rapid absorption favor increased bone replacement but also raise local pH, which can inhibit bone remodeling and affect long-term effectiveness.[25] Because they are fragile and present low mechanical strength, their use becomes limited in areas that require load-bearing.[18]

Polymers, many of which are also known as *resins*, are macromolecules formed by the polymerization of smaller molecules. The most commonly used natural polymers in bone tissue engineering are collagen, chitosan, gelatin, silk fibroin, alginate, cellulose, and starch.[26] Their high biocompatibility and low toxicity make them attractive for clinical applications, and their degradation products are generally non-toxic and easily reabsorbed by the body. A marketed Brazilian product is castor oil polyurethane, but its effectiveness is debated in the scientific literature.[27]

Biodegradable synthetic polymers, such as polylactic acid (PLA), poly(lactic-co-glycolic acid) (PLGA), and polycaprolactone (PCL), stand out in tissue engineering due to their ability to adjust physical properties, including porosity, osteoconductivity, resorption rate, and final conformation. [1,5,6] These characteristics make them particularly suitable for customized implants, especially through techniques such as 3D printing.[5] In addition, the low immunogenicity of these materials is a significant advantage, contributing to their biological acceptance. However, during degradation, a reduction in local pH may occur, potentially compromising the adhesion of osteoprogenitor cells and the material's osteoconductive properties.[18] The use of biodegradable polymers is still relatively recent and requires further studies to consolidate the evidence and develop application guidelines.

A non-absorbable synthetic polymer, PMMA is widely used in orthopedics for the fixation of prostheses,[28] the filling of bone defects, mechanical reinforcement in cases of fragile bones, such as in vertebroplasties, to increase the mechanical resistance of osteosyntheses,[4] or to carry drugs such as antibiotics and chemotherapeutics.[29,30] When PMMA is introduced into bone defects, it forms a solid, compact mass that functions as a biotolerant spacer with no bone integration.[14,31]

The PMMA cement offers advantages such as unlimited availability, immediate mechanical stability, ease of intraoperative molding, and affordability. However, its limitations include the exothermic reaction during formation, which can lead to overheating and bone necrosis.[32] Although its possible adjuvant effect in the treatment of aggressive tumors due to high temperature is discussed, this has not been proven yet. Bone cement loosening is a significant limitation, associated with bone resorption and fibrosis layer formation, easily detectable on radiographs, and usually stabilizes after 3 months.[33] A likely cause of this condition is the difference in elasticity between cement and cancellous bone, which leads to micromovements and bone resorption.[31] Away from the joints, the marginal sclerosis that surrounds the cement has no implications. However, in the subchondral region, bone resorption can result in fractures, joint incongruence, and arthrosis.[29] Finally, the definitive presence of cement prevents bone remodeling and hinders future interventions, which is its main disadvantage[14] (►**Fig. 3**).

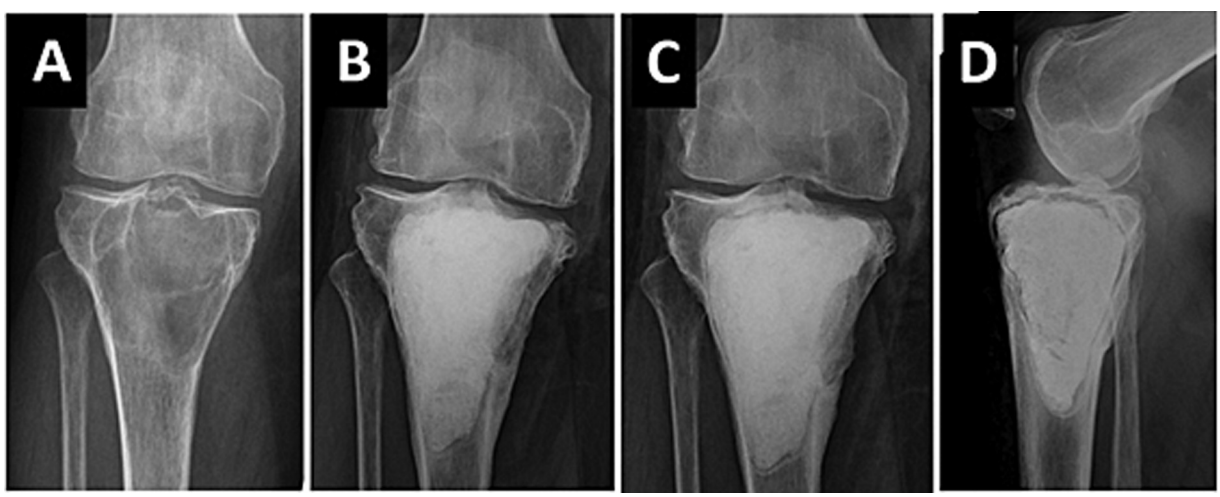


Fig. 3 Radiographs of the proximal region of the tibia showing a giant cell tumor compromising the subchondral bone of the medial condyle (**A**). Two years (**B**) and 4 years (**C**,**D**) after surgery, bone resorption is observed around the cement block, more pronounced in the subchondral region. This reabsorption can lead to fracture, arthrosis, and even intra-articular exposure of the cement.

Metals are well known to orthopedists and other professionals who perform osteosynthesis. Titanium (Ti) and chromium-cobalt (CoCr) steel plates, nails, and screws are biocompatible and present high mechanical strength and wear resistance.[4] The use of metals as bone substitutes became feasible with the advent of 3D printing (additive manufacturing, AM), enabling the production of defect-shaped parts from computed tomography scans. However, stress shielding, resulting from differences in metal and bone elasticity, is the main criticism to their use as bone substitutes, as it transfers mechanical stresses from the bone to the stiffer metal, reducing the mechanical osteoinducive stimulus on the bone and promoting its resorption.[4]

To adjust the modulus of elasticity and promote osseointegration, these structures are produced with pores of variable size and quantity, and the metal alloy formulation can also be adjusted. Titanium is the most commonly used metal. The addition of tantalum (Ta) to Ti alloys further reduced the modulus of elasticity.[34] Biodegradable metals based on iron (Fe) and magnesium (Mg), which can already be produced by 3D printing, represent a promising innovation. Porous iron structures demonstrated resorption rates of 5 to 16% in 4 weeks, maintaining a modulus of elasticity comparable to that of cancellous bone in this period. Another approach under development is the creation of semi-absorbable Ti and Mg alloys,[35] evidencing a rapidly-evolving field of research with significant advances.

Osteoinducers

Many osteoconductive bone substitutes can be used in combination with osteoinductors to enhance osteointegration. Simple impregnation of the bone substitute in bone-marrow aspirate may have an osteoinductive effect.[36] The first osteoinducers identified were bone morphogenetic proteins (BMPs),[1] a group of molecules classified as *growth factors*, belonging to the transforming growth factor β (TGF-β) superfamily.[6] They are produced by osteoblasts and play an important role in the recruitment and differentiation of osteoprogenitor cells in bone-formation sites. Despite several studies, the effectiveness of these components is controversial and lacks clinical evidence. The main limitations include the high solubility—which makes it difficult to fix the protein to the desired location—the high cost, and the risk of BMP escape, with the possibility of ectopic ossification in unwanted areas.

Among the growth factors, fibroblast growth factor (FGF) has already been used in clinical studies, although the mechanism of osteoinduction is not well understood. It is known that FGF is present throughout the fracture consolidation process, but its effect depends on the dose and the time of application.[6] Although studies have shown its positive effect, its clinical use has not yet been approved by regulatory agencies.

Vascular endothelial growth factor (VEGF) has two functions related to osteoinduction: direct effect on osteogenesis and on bone callus vascularization in fractures.[37] Concern regarding the induction of hemangioma formation and tumor recurrence, especially in those sensitive to VEGF, may restrict its use.[6]

The parathyroid hormone (PTH) is commercially available and used to increase bone mass and reduce fractures in patients with osteoporosis. Studies[6] have shown that its use results in increased bone mass and shorter fracture consolidation time; however, there is no evidence that PTH initiates the bone remodeling or consolidation process.

Bioinorganic ions such as silicon, Mg, strontium, zinc, and copper play important roles in the body, including serving as enzyme cofactors, coenzymes, signaling molecules, and regulators of ion channels. Some of these functions are related to osteogenesis, and their osteoinducive properties have been widely studied and frequently confirmed. In addition, the incorporation of these ions in base materials presents advantages, such as low cost, longer shelf life, and probable reduction of risks compared to growth factors. However, robust evidence is still lacking to support regulatory approval of substitutes containing these ions as osteoinducers.[6,38]

An osteoinducive factor that should not be overlooked is the mechanical factor. Cyclic bone deformation activates osteoblasts and promotes bone remodeling.

Absence of filling

Some authors[19,30] consider bone defect filling unnecessary in certain clinical situations because they observe high rates of bone neoformation induced by mechanical stimulation. In these cases, remodeled bone appears different from normal bone but may still have sufficient mechanical strength to support the functional load. The risk of fracture before complete bone remodeling is mitigated by prophylactic osteosynthesis, which can prevent mechanical complications and enable early load support, a situation not always possible with bone substitutes.[19] Therefore, bone grafts and substitutes can only be considered effective if their remodeling potential is greater than that of natural bone remodeling (►**Fig. 4**).

Advances

The emergence of various synthetic bone substitutes offers a wide variety of options. However, the treatment outcome is still incomparable to that of autologous bone graft in terms of bone healing quality and time. Overall, the effectiveness of the substitutes available still depends on a favorable site and the size of the defects.

The most significant recent advances in osteoinducers involve increased production and reduced cost of growth factors through recombinant technology. Recombinant human BMPs (rhBMPs), which have demonstrated reasonable osteoinductive activity,[39] as well as the understanding of the osteoinducive effect of bioinorganic ions is an important and promising line of research.[6]

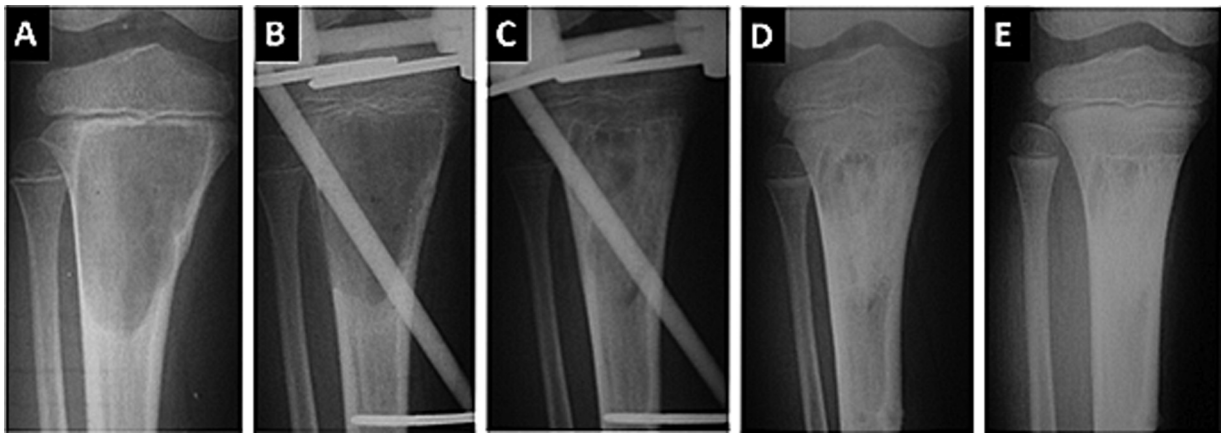


Fig. 4 Serial radiographs of a 5-year-old patient with aneurysmal bone cyst in the tibia, adjacent to the growth cartilage (**A**). The patient underwent curettage and installation of a transphyseal external fixator, without filling the defect (**B**). Five months after surgery, at the time of fixator removal (**C**), progressive bone remodeling is observed, which continues 6 months (**D**) and 12 months (**E**) postoperatively. The growth cartilage remained intact.

The development of metal substitutes with mechanical properties compatible with those of cortical bone, low toxicity, and large and interconnected pores, enabling osteointegration, has shown good results. The absorbable metals that can be produced by 3D printing[4] arouse great interest, as does 3D bioprinting with active cells such as osteoblasts and osteoclasts.[35]

The application of tissue engineering to musculoskeletal pathology has uncovered potential treatment strategies. Regional gene therapy involves the local implantation of nucleic acids or cells genetically modified to direct specific protein expression, and it has shown promise as a bone regeneration technique.[40]

With recent advances in tissue engineering, a new approach has emerged focused on "tissue regeneration by natural tissues," rather than "tissue replacement by biomaterials." Coculture and triculture of different cell types in CPC structures offer great potential to promote vascularization in bone regeneration, especially in the treatment of large bone defects.[6] However, more studies are required to validate these approaches and elucidate the underlying mechanisms to advance tissue engineering and regenerative medicine.

Conclusion

The treatment of bone defects is a major challenge for surgeons. The gold standard is still the autologous graft, but its use faces restrictions such as limited availability and surgical complications.

Despite technological advances in this field, substitutes have not yet achieved the clinical effectiveness of the autologous graft. Whether due to bioavailability limitations, osteoinduction, osteoconduction, or cost, the search for a bone substitute that reconciles all these variables remains a challenge for the scientific community.

The high number of bone replacements worldwide, coupled with the commercial potential of an effective biomaterial, has driven significant advances in the field. New technologies in molecular biology, AM, gene therapies, and tissue bioengineering offer a promising horizon for the development of bone substitutes.

Data Availability

Data will be available upon request to the corresponding author.

Authors' Contributions

Each author contributed individually and significantly to the development of this article. EEE: conceptualization, validation, visualization, writing – original draft, and writing – review & editing; NFG: conceptualization, visualization, and writing – original draft; MAS: conceptualization, visualization, writing – original draft, and writing – review & editing; LGB, LKI, and LFMM: writing – original draft.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Use of the Groin Flap in Traumatic Hand Injuries

Emprego do retalho inguinal nas lesões traumáticas da mão

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Abstract

Objective To analyze the use of the groin flap in the treatment of traumatic injuries that are not very extensive, with tissue loss in the wrist and hand region.

Methods We performed 14 flaps from the inguinal region to reconstruct traumatic hand injuries. The age of the sample ranged from 21 to 56 years, and all patients were male.

Results Complete flap survival was recorded in all limbs. In seven patients, there were complications: in two, partial necrosis, for which flap debridement was necessary, and the area was covered with a skin graft. In four cases, marginal necrosis occurred, which later healed spontaneously. Partial loosening at the receiving area was observed in one case in the first week, requiring complete suturing.

Conclusion Even with the advent of microsurgical techniques, the groin flap remains a good and safe method to repair hand injuries with tissue loss, with or without loss of bone tissue.

Keywords

- hand injuries
- iliac artery
- skin graft
- soft tissue injuries
- surgical flaps

Resumo

Objetivo Analisar o emprego do retalho inguinal no tratamento de lesões traumáticas com perda tecidual, não muito extensas, na região do punho e mão.

Métodos Foram realizados 14 retalhos da região inguinal para a reconstrução de lesões traumáticas das mãos. A faixa etária foi de 21 a 56 anos, e todos os pacientes eram do sexo masculino.

Resultados A sobrevida completa do retalho foi registrada em todos os membros. Em sete pacientes houve complicações: em dois, necrose parcial, sendo necessário desbridamento do retalho, e a área foi revestida com enxerto de pele. Em quatro casos, ocorreu necrose marginal, que cicatrizou tardiamente de forma espontânea. A soltura parcial na área receptora foi registrada em um caso, na primeira semana, sendo necessário completar a sutura.

Conclusão Mesmo com o advento das técnicas microcirúrgicas, o retalho inguinal continua a ser um método bom e seguro de reparo de lesões com perda tecidual da mão, com ou sem perda tecido ósseo.

Palavras-chave

- arteria ilíaca
- enxerto de pele
- lesões da mão
- lesões dos tecidos moles
- retalhos cirúrgicos

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Introduction

Proper coverage of complex hand injuries with tissue loss is a common yet challenging issue for hand surgeons, especially when structures such as bones, tendons, nerves, and blood vessels are exposed. In most cases, these are due to severe trauma caused by circular saws, presses, and machinery used in mechanics and agriculture, for example. Several flaps have been described to cover these injuries,[1,2] and one of them, which is used for hand injuries with soft tissue loss, is the groin flap, initially described by MacGregor and Jackson[3] in 1972, and widely used to the present day.[3–6]

An ideal flap to cover injuries with tissue loss should present a low risk of surgical complications, not have a visible scar in the donor area, not present functional deficit, provide adequate quantity and quality of tissue, and have a consistent vasculo-nervous pedicle of adequate length and easy to dissect. Although this donor area has not yet been described, the groin flap offers many advantages, including reliable anatomy, minimal volume, easy adaptation to the recipient area, and minimal donor-area morbidity. In addition, it can also be used as an osteocutaneous flap by including the iliac crest. For all these reasons, the groin flap remains widely used for its simplicity, safety, and versatility.[3–13] A disadvantage of this procedure is the need to keep the hand close to the groin during the healing period, which lasts about 3 weeks and is very uncomfortable for the patient. In addition, because it has a short pedicle, it is difficult to use it as a free flap, and it lacks the potential for motor innervation, making it unsuitable as a functional flap.[5–8]

Covering the injury site with appropriate soft tissue is essential to improve function.[1,2,5] Optimal coverage must be stable, durable, and able to withstand heavy work demands; preserve joint mobility; and have an esthetically acceptable appearance, while always prioritizing function.[5–8]

The objective of the current study was to present our experience and evaluate the outcomes of the groin flap for the reconstruction of tissue losses of the hands that are not very extensive, with or without bone tissue loss.

Materials and Methods

Anatomy

The groin flap is a fasciocutaneous flap, supplied by the superficial iliac circumflex artery; the venous return is provided by the vein of the same name, which is next to the artery. The superficial iliac circumflex artery and vein originate from the femoral artery and vein, about 2 cm distally to the inguinal ligament, which joins the pubic tubercle to the anterior superior iliac spine, separating the abdomen from the lower limb. The superficial iliac circumflex artery and vein are positioned 2 cm distally to the inguinal ligament and run parallel to it, with this being the center of the flap.[3–7,14] Regarding the groin flap length, it can extend several centimeters beyond the anterior superior iliac spine, but the width should not exceed 10 cm. Medially, the flap should not extend beyond the femoral artery, which should be located by palpation and marked; it is safer to complete the flap dissection at a distance of 2 cm laterally from the artery (►**Fig. 1**).

Clinical material

A total of 14 fasciocutaneous groin flaps were performed, and, in 3, it was necessary to include a bone segment of the iliac crest (►**Figs. 2**–**4**). The flaps were used for hand and finger reconstruction between 2001 and 2017. The age of the

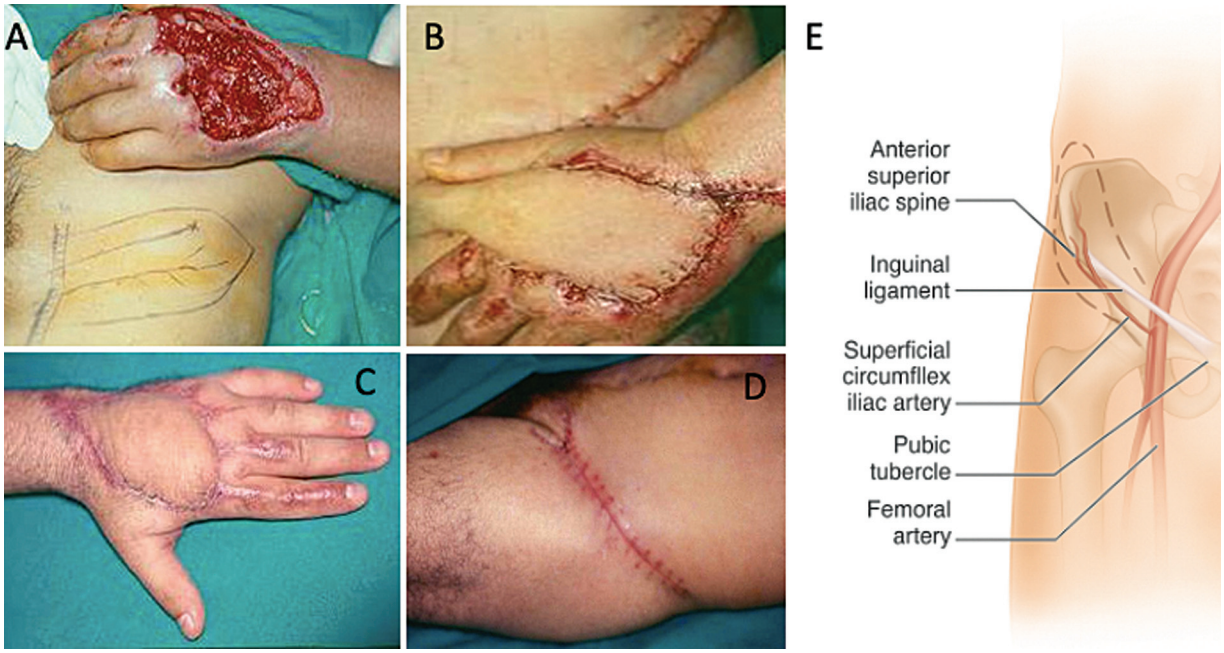


Fig. 1 (**A**) Flap design in the donor area; (**B**) flap sutured in the receiving area; (**C**) result in the receiving area; (**D**) result in the donor area; and (**E**) schematic drawing with the marking of the anatomical elements surrounding the flap.

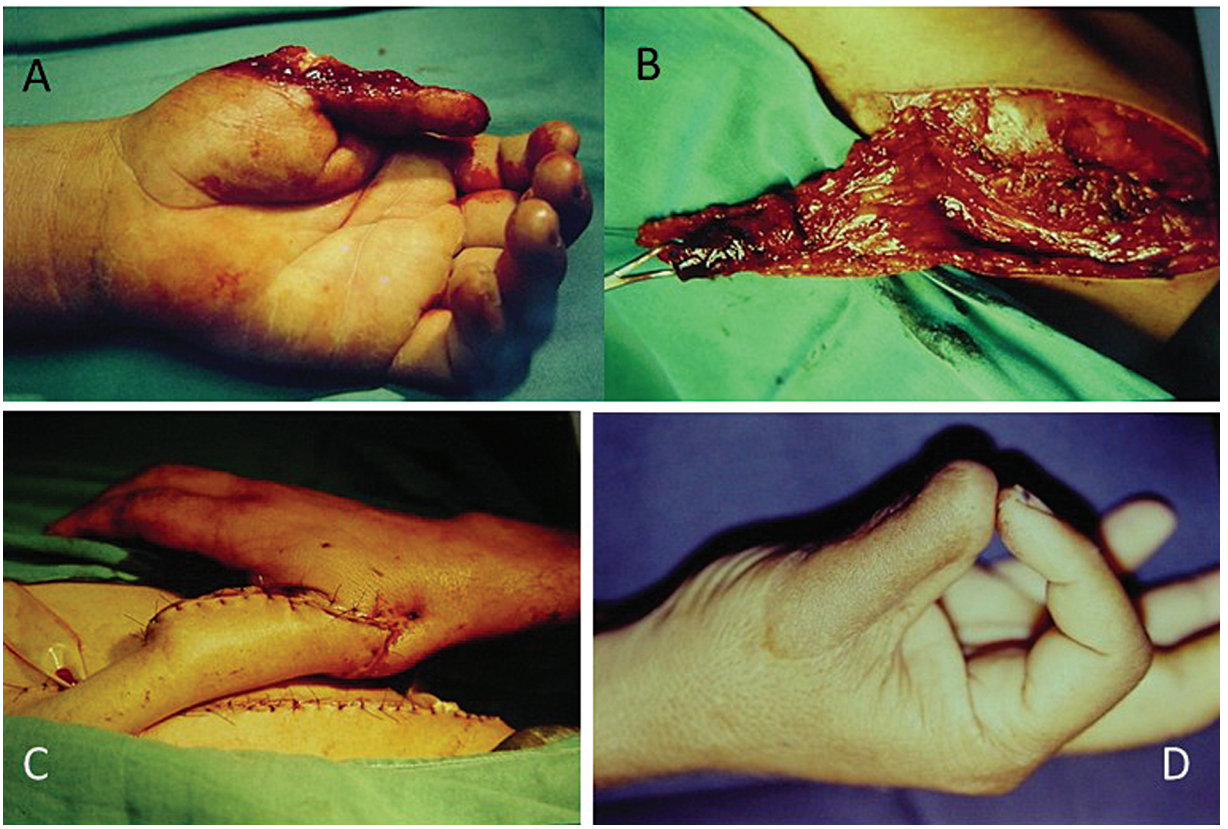


Fig. 2 (**A**) Osteocutaneous loss of the thumb; (**B**) groin flap with bone inclusion of the iliac crest; (**C**) flap sutured in the receiving area; and (**D**) final result.

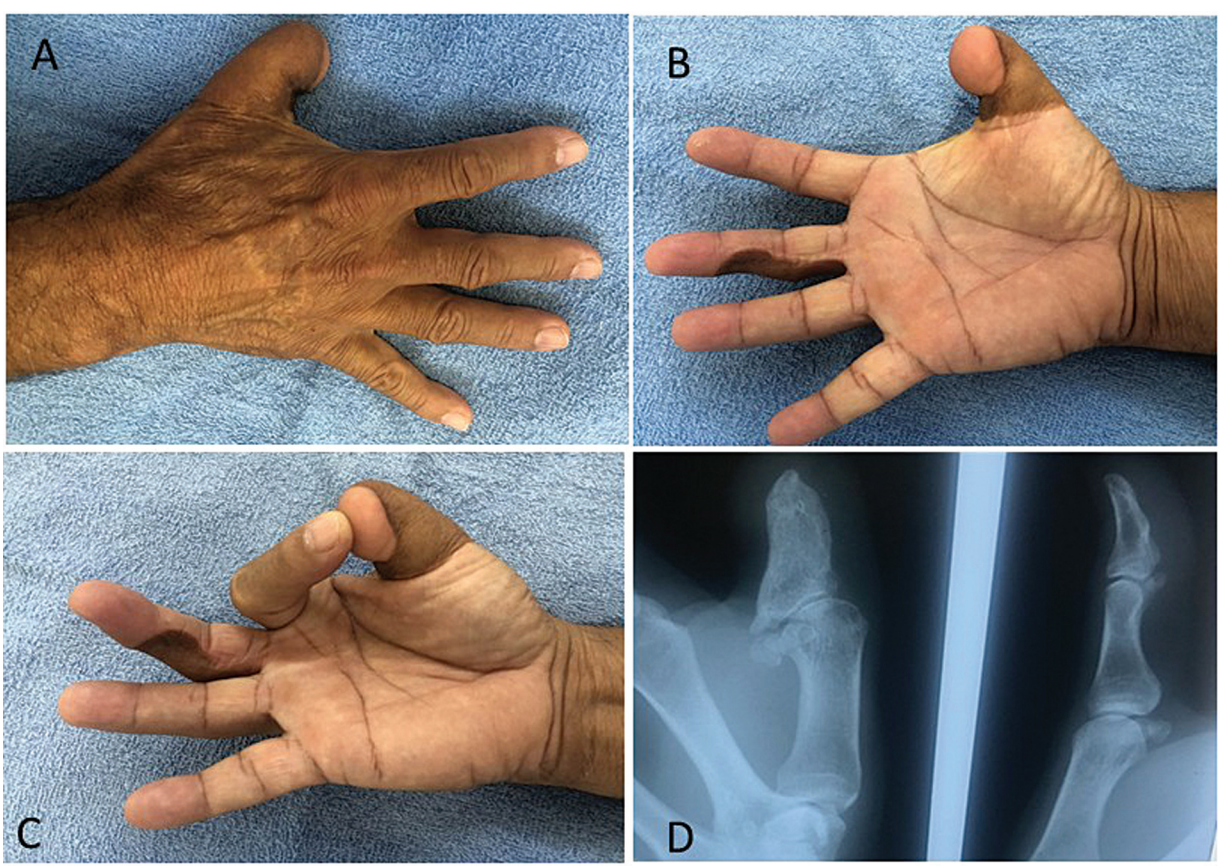


Fig. 3 (**A**) Reconstruction of the amputated thumb with osteocutaneous flap of the groin region; (**B**,**C**) neurovascular island flap from the middle finger to the thumb; And (**D**) radiograph of the bone flap of the reconstructed finger next to the normal thumb.

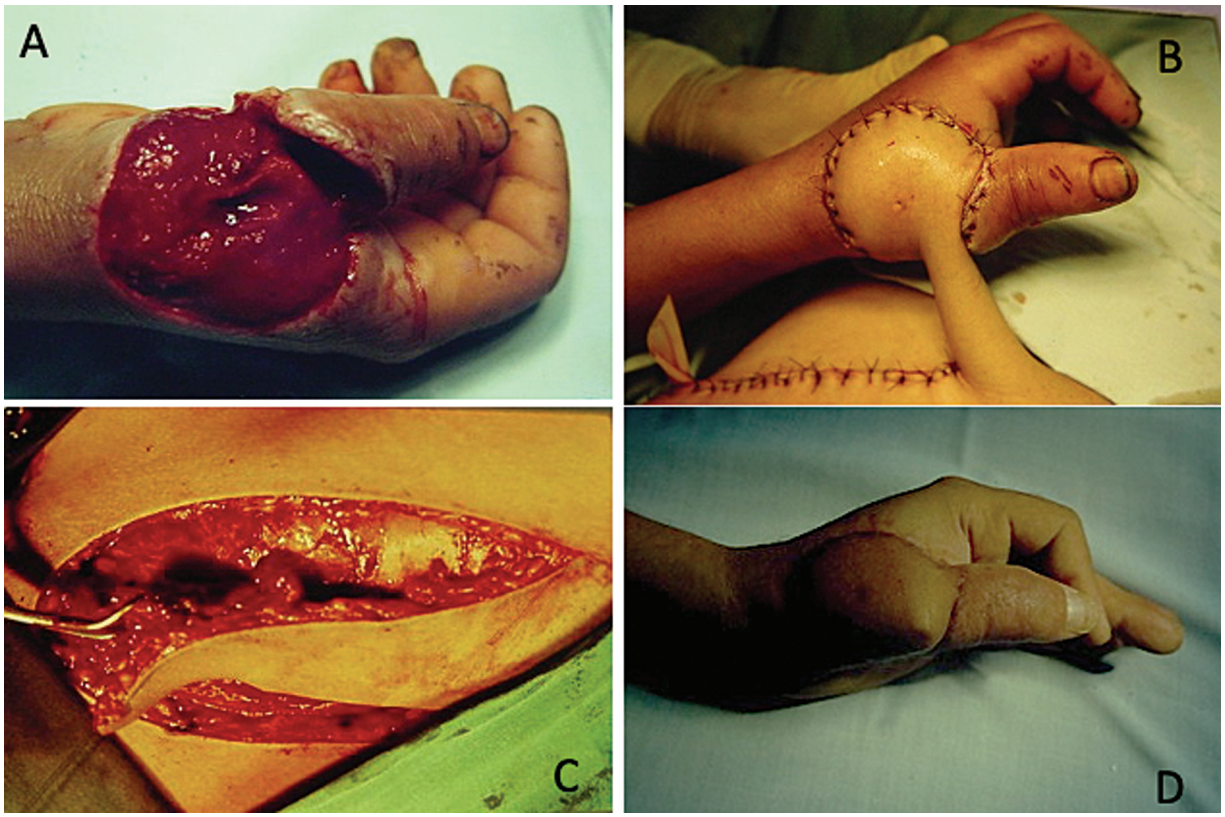


Fig. 4 (A) Osteocutaneous loss of the first metacarpal; (B) osteocutaneous flap with inclusion of the iliac crest; (**C**) osteocutaneous flap; and (**D**) final result.

sample ranged from 21 to 56 years, and all subjects were male. The injuries ranged in size from 5 × 8 cm to 10 × 18 cm. Surgical procedures were performed 2 to 8 days after the injury occurred. The pedicle was only disconnected from the donor area between 21 and 24 days. In most cases, the injuries resulted from workplace accidents involving presses, industrial machines, and circular saws. In two patients, injury to the extensor tendons occurred (►**Figs. 5**–**6**), and, in four, bone injury, including fractures and bone tissue loss (►**Figs. 2**–**6**). There was one case of tissue loss of the palmar and dorsal surfaces of the middle and annular fingers (►**Fig. 7**).

Surgical procedure

The patient was positioned in dorsal decubitus. The flap was demarcated according to the needs of the receiving area. The skin, the subcutaneous tissue, and the fascia were included. In four patients with bone loss of the thumb, a segment of the iliac crest was included in the flap. The inclusion of the fascia is part of the procedure, as the vessels (superficial iliac circumflex artery and vein) are positioned on it. Dissection should be performed carefully, using a magnifying glass and electrocautery. After closing the donor area with slight tension, the procedure of covering the receiving area was completed. With a sufficiently-loose pedicle, a tube can be formed from it to leave only a minimum exposed area (►**Fig. 2**). As the flap would only be untied after 3 weeks and, during this period, the patients should keep their hand close to the groin, the procedure was performed with the limb bandaged close to the body. It was not necessary to apply an external fixator in any of the cases. All patients were discharged the day after the procedure, and they were properly instructed to keep their hand in the vicinity of the donor area.

The current study was approved by the institutional Research Ethics Committee under the number CAAE: 83985818.7.0000.5373.

Results

In 7 of the 14 limbs, no postoperative complications were observed, with primary and complete healing of the donor and recipient areas. Complete flap necrosis was not recorded in any limb. Among the seven complications were partial necrosis in two cases, which required flap debridement, and the area was covered with a skin graft; in four cases, there was marginal necrosis, which later healed spontaneously; partial loosening in the recipient area occurred in one case, in the first week, requiring completion of the suture (►**Fig. 8**) In none of the cases was the flap compromised by the patients' removal of the bandaged before the flap was unlinked.

Late treatment outcomes were assessed in 10 patients, with a mean follow-up of 24 weeks after surgery. Pain in the hand was reported by most patients, especially those involved in workplace accidents. Some patients had limitations in digital flexion or extension. Some patients also reported

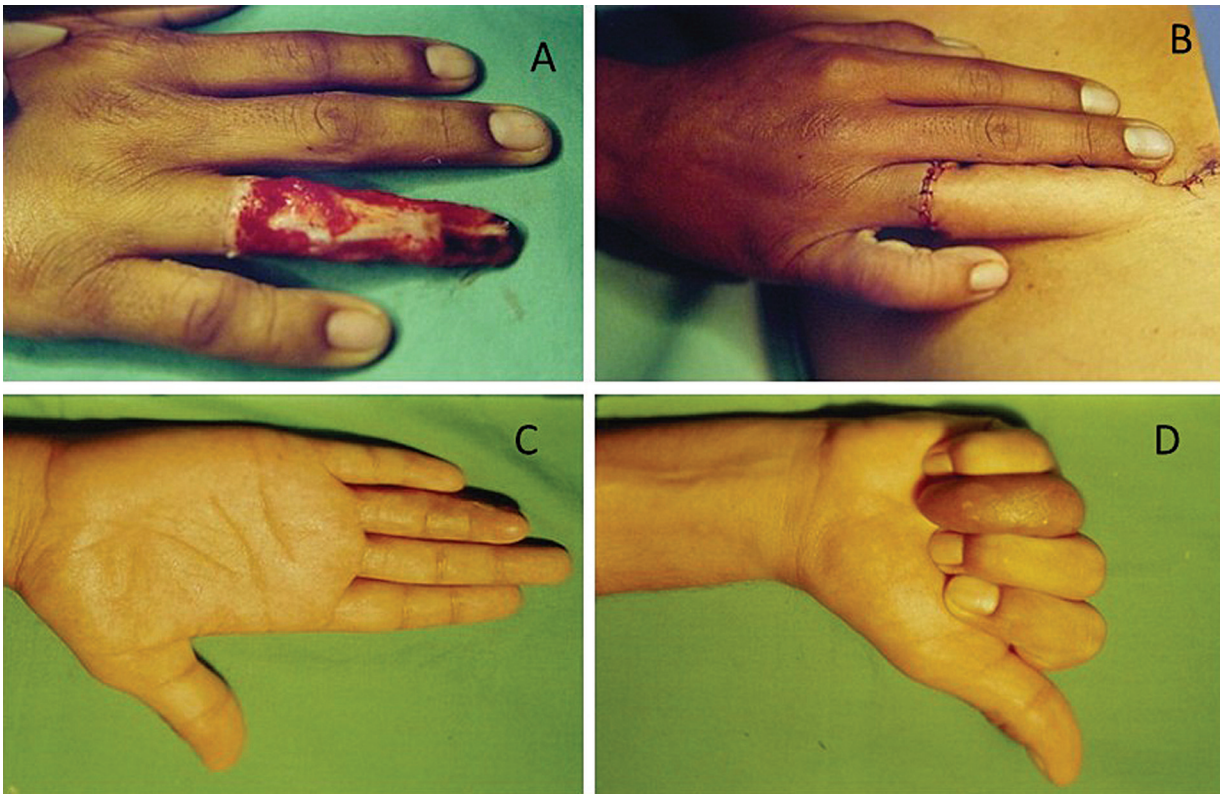


Fig. 5 (**A**) Dorsal ring finger injury; (**B**) flap from the inguinal region; (**C**) aspect with finger extension; and (**D**) aspect with finger flexion.

pain in the donor area, especially after exertion or a long walk, but none had mobility limitations in the lower limb.

Discussion

In the current study, we present the outcomes of 14 groin flaps for the reconstruction of hand and finger injuries between 2001 and 2017. In three patients with bone loss of the thumb, a segment of the iliac crest was included in the flap. The inclusion of the fascia is part of the procedure, as the vessels (superficial iliac circumflex artery and vein) are positioned on it. The age of the sample ranged from 21 to 56 years, and all subjects were male. The injuries ranged in size from 5×8 cm to 10×18 cm. Surgical procedures were performed 2 to 8 days after the injury occurred. The pedicle was only disconnected from the donor area between 21 and 24 days in 9 of the 14 limbs. There were no postoperative complications, and the donor and recipient areas healed completely. Complete flap necrosis was not recorded in any limb. Complications occurred in seven cases: in one case, partial necrosis; in two cases, flap debridement was required, and the area was covered with a skin graft; in 4, marginal necrosis occurred, which later healed spontaneously; and partial loosening in the receiving area was observed in one case in the first week, and the suture had to be completed.

Żiluk[5] reported the outcomes of the treatment with a groin flap in 31 patients with upper-limb tissue loss, 28 male and 3 female subjects. In total, 23 patients had primary healing without problems in the donor and recipient areas.

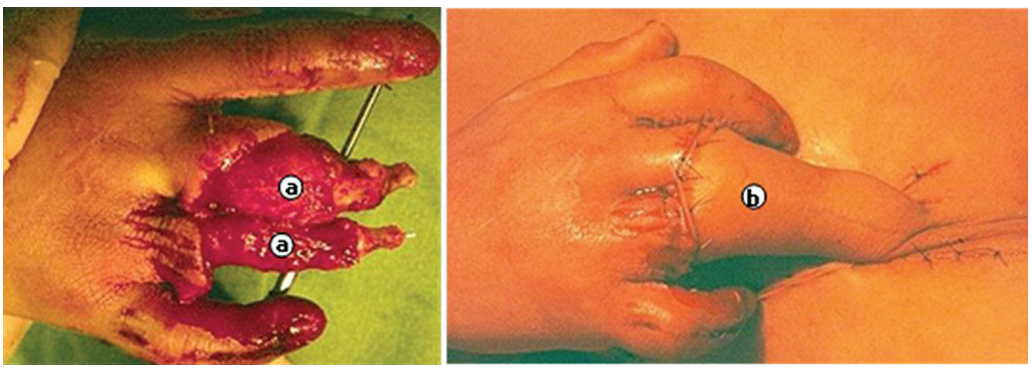


Fig. 6 (**A**) Injury to the middle and ring fingers with tissue loss; and (**B**) cover with a groin skin flap.

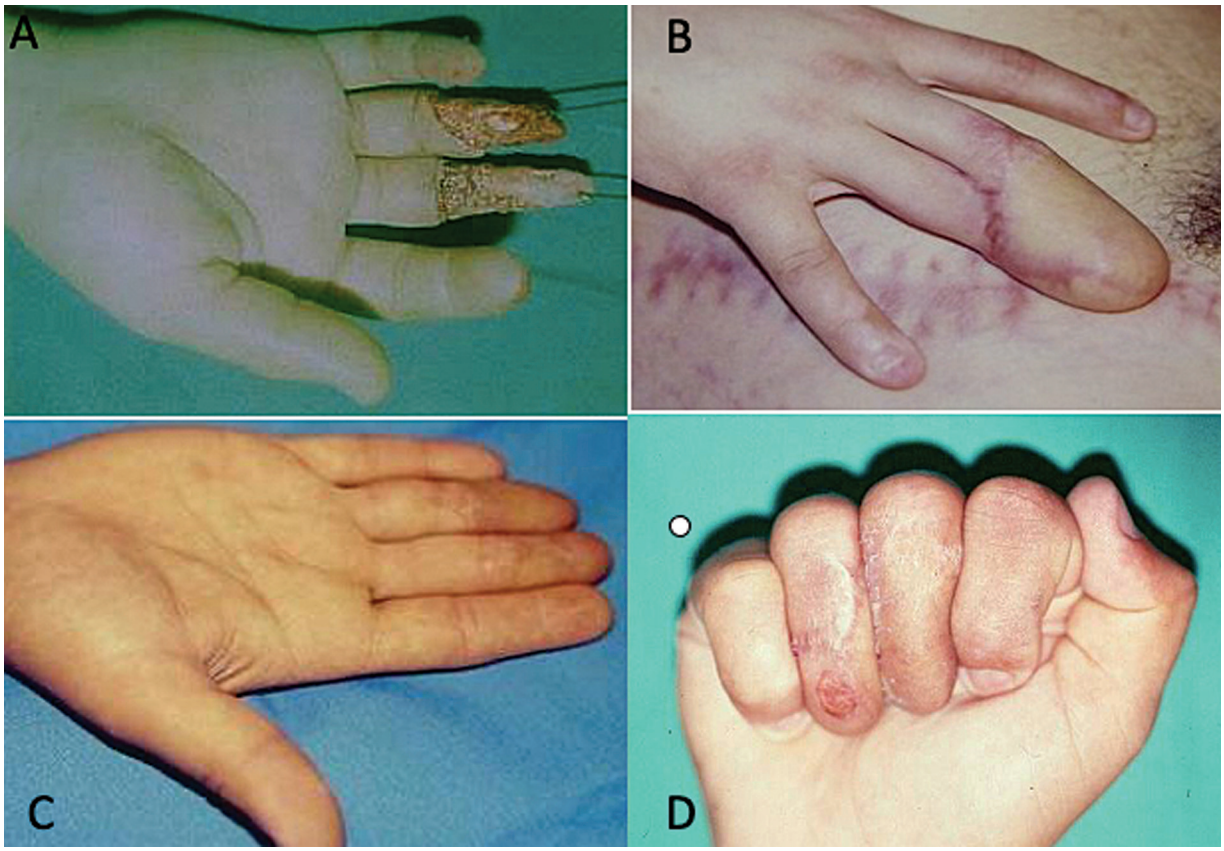


Fig. 7 (A) Tissue loss of the palmar and dorsal surfaces of the middle and annular fingers; (B) donor and recipient areas of the flap; (C) separation of the fingers in extension; and (D) aspect with digital flexion.

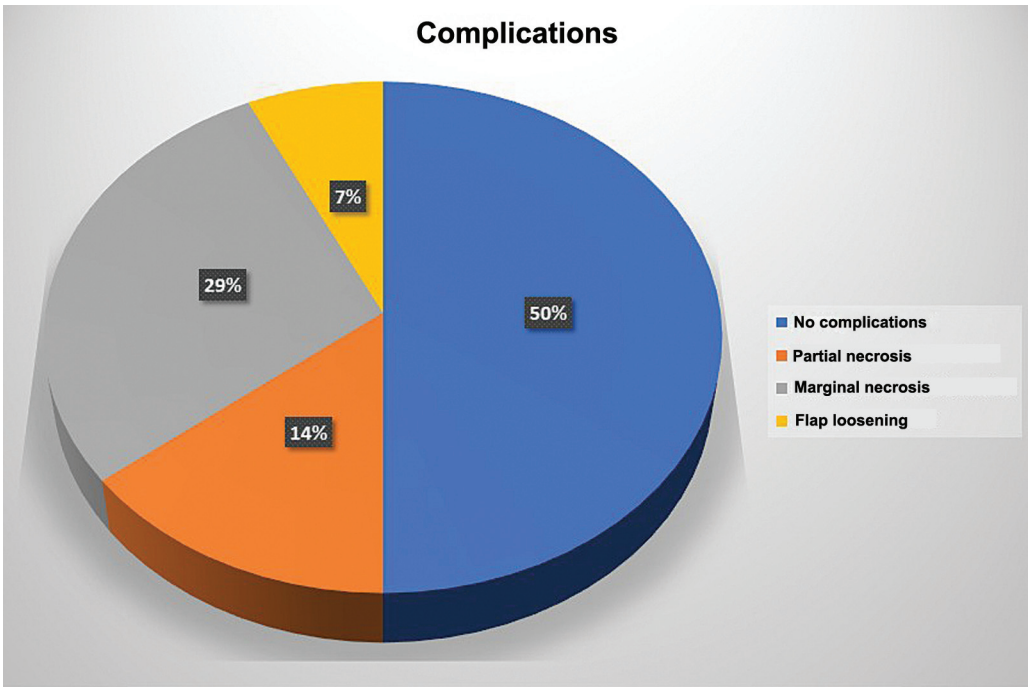


Fig. 8 Graph with results on complications.

Complications were recorded in eight patients: in one, total flap necrosis occurred; in three, marginal necrosis, which required additional skin grafting after the flap was separated from the donor area; in two cases, the flaps were partially disconnected from the donor area, and a skin graft was required; and two patients had delayed healing in the donor area. The author[5] reports that the advantages of the groin flap outweigh its disadvantages, and that the outcomes of the study show that groin flaps are useful for reconstructing upper-limb soft-tissue loss.

Naala et al.[8] reported the outcomes of groin flaps in 85 patients with upper-limb soft-tissue loss, 78 male and 7 female subjects, with a mean age of 27 years. In 99% of the cases, there was good flap integration; in one patient, there was a total flap loss. The outcomes were satisfactory in most subjects, with good functional outcomes. However, complications were recorded in 22 out of the 85 patients. Marginal necrosis occurred in 10 limbs. Partial flap necrosis requiring skin graft repair occurred in 6 limbs, and local infection occurred in 4 limbs. Flap detachment requiring new surgical fixation occurred in 2 patients. According to the authors,[8] although more recent reconstruction techniques have been developed, the groin flap remains a safe and effective method for repairing upper-limb injuries with tissue loss.

Hayashi et al.[10] reported the use of the groin flap in soft-tissue losses in a reimplanted limb, with the groin flap covering the dorsal and palmar faces of the forearm. The flap healed without complications, with a satisfactory functional outcome.

Abdelrahman et al.[11] reported a modification of the groin flap method, using it without including the fascia. Anatomical studies have revealed that the superficial iliac circumflex artery is sufficient for a relatively-large segment of the flap to receive adequate blood supply without the inclusion of fascia. Naala et al.[8] presented the treatment outcomes in 77 patients with upper-limb tissue loss: the flap with fascia inclusion was used in 49 limbs, and without fascia inclusion, in 28 limbs. The treatment outcomes were satisfactory, and complications were low in both groups.

Jabaiti et al.[12] reported the outcomes of the groin flap in 34 patients, 31 male and 3 female subjects: digital injuries were the most frequent, occurring in 16 limbs. The mean injury area was of 44 (range: 12–162) cm^2. Good outcomes were observed in 29 patients; however, in 1, total flap necrosis occurred; and in 4, partial flap necrosis occurred. All patients declared their satisfaction with the outcomes. The authors[12] consider that, even in the era of advanced microsurgery, the groin flap remains an excellent option for covering injuries with moderate-to-large tissue loss, and that its advantages outweigh its disadvantages.

In their first study, Molski et al.[13] reported outcomes in 97 patients with tissue defects or scar deformities in the hands, including 87 men and 10 women with a mean age of 25 years. Depending on the defect sizes, the flaps were 7 cm to 26 cm long and 4 cm to 12 cm wide. In 59 patients (61%), surgery was performed immediately after or within a few days of the lesion, while, in the remaining 38 patients, it was delayed.

Marek[15] used the osteocutaneous groin flap in eight patients to repair bone loss in metacarpals and phalanges. Flap healing was achieved in all patients, although complications, including surgical wound infection, partial flap necrosis, and an inflammatory reaction at the suture sites, were observed in 7 limbs. The author[15] concluded that the osteocutaneous groin flap is a good solution for associated bone and soft-tissue losses.

Gupta et al.[16] presented the outcomes of the groin flap in 25 children aged 9 years or older who suffered hand tissue loss as a result of electrical burns. In most cases, the losses involved exposure of tendons and bones. Flap healing was achieved in all cases, including two cases of partial necrosis requiring skin graft coverage. Suture dehiscence was also observed in the donor area in two children. Tests performed on average 1 year after surgery showed good functional outcomes. The children were well, able to play and perform their daily activities normally.

Devarasetty et al.[17] conducted a study involving 88 pedicled groin flaps used to cover upper-limb injuries. The patients had a median age of 35 years and underwent a mean of 4 surgeries throughout the treatment. The most commonly observed complication was finger stiffness. Other common complications were partial flap loss (in 38% of the cases) and infection (in 32%). This study reported a higher partial flap loss rate than that of our sample, which showed only 14%. High-energy injuries are more likely to require more procedures during treatment. The analysis revealed no significant differences in wound complications across patient or injury characteristics.

Conclusion

The treatment outcomes of injuries to the hands that are not very extensive, with or without bone tissue loss, using the groin flap, were satisfactory. Even with the advent of microsurgical techniques, the groin flap remains a good and safe method for repairing hand injuries with tissue loss, with or without bone loss.

Data Availability

Data will be available upon request to the corresponding author.

Authors' Contributions

Each author contributed significantly to this article. EC, LV, and JS: writing – original draft, statistical analysis, conceptualization, and development of the research project; and VB, VT, and KC: data collection, data analysis, writing – original draft, and writing – review & editing.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Implant Removal Complications in Pediatric Orthopedics

Complicações na remoção de implantes em ortopedia pediátrica

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Abstract

Objective Implant removal is a common practice in pediatric orthopedics, despite its risks. The present study aims to evaluate postoperative complications following implant removal in pediatric patients, correlating them with epidemiological factors.

Methods Retrospective cross-sectional study, conducted in a tertiary hospital, with analysis of medical records and imaging exams from February 2021 to June 2024. Medical records of patients under 18-years-old who were followed up until outpatient discharge were evaluated. The research included age, sex, type of implant, indication for insertion and removal, time to implant removal, and postoperative complications, which were classified according to Clavien-Dindo.

Results A total of 202 medical records were analyzed. Implant removal was more common in boys, with a mean age of 12 years, and the mean time to removal was 16 months. The main reason for placement was orthopedic trauma, and for removal, bone consolidation. The complication rate was 10% (n = 22). Plate removal had the highest complication rate (15%), followed by isolated screws (14%), external fixators (12%), flexible nails (10%), and Kirschner wires (8%). The main complications were unsuccessful removal (45.5%), superficial infection (36.5%), refractures (9%), and movement limitation (9%). The Clavien-Dindo classification revealed 45.45% type I complications, 40.9% type II complications, and 13.6% type IIIa complications.

Conclusion Implant removal in pediatric orthopedics is not without complications, with 11% being found in this study. Failure to completely remove the implant, superficial infections, and refractures were the most common. Before the procedure, the risks and benefits involved should be considered and consensus should be reached among family members and surgeons.

Keywords
- device removal
- orthopedics
- pediatrics
- postoperative complications

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Resumo

Objetivo A remoção de implantes é uma prática comum na ortopedia pediátrica, apesar de seus riscos. Este estudo visa avaliar as complicações pós-operatórias da remoção de implantes em pacientes pediátricos, correlacionando-os com fatores epidemiológicos.

Métodos Estudo transversal retrospectivo, realizado em um hospital terciário, com análise de prontuários e exames de imagem entre fevereiro de 2021 e junho de 2024. Foram avaliados prontuários de pacientes menores de 18 anos, acompanhados até a alta ambulatorial. A pesquisa incluiu idade, sexo, tipo de implante, indicação da inserção e retirada, tempo de permanência do implante e complicações pós-operatórias, que foram classificadas de acordo com Clavien-Dindo.

Resultados Foram analisados 202 prontuários. A retirada de implantes foi mais comum em meninos, com média de idade de 12 anos e tempo médio de permanência de 16 meses. O principal motivo da colocação foi trauma ortopédico, e o da remoção, consolidação óssea. A taxa de complicações foi de 10% (n = 22). A remoção de placas teve a maior taxa de complicações (15%), seguida por parafusos isolados (14%), fixadores externos (12%), hastes flexíveis (10%) e fios de Kirschner (8%). As principais complicações foram retirada malsucedida (45,5%), infecção superficial (36,5%), refraturas (9%) e limitação de movimento (9%). A classificação de Clavien-Dindo revelou 45,45% de complicações tipo I, 40,9% tipo II e 13,6% tipo IIIa.

Conclusão A remoção de implantes dentro da ortopedia pediátrica não é isenta de complicações, sendo encontradas 11% neste estudo. A retirada completa malsucedida do implante, infecções superficiais e refraturas foram as mais comuns. Antes do procedimento, os riscos e benefícios envolvidos devem ser considerados, sendo necessário um consenso com familiares e cirurgiões.

Palavras-chave

- complicações pós-operatórias
- ortopedia
- pediatria
- remoção de dispositivo

Introduction

Implant removal after fracture consolidation is a prevalent procedure in orthopedic practice.[1] It is estimated that 6% of all orthopedic procedures are implant removals, and in the pediatric population, this rate can reach 6.7%.[2]

There is still no clinical guideline to determine the indication and timing of implant removal, making this a topic of discussion in the orthopedic community.[3]

The benefits of removing the implants include the prevention of biological and functional sequelae, such as tumor induction, infection, inflammation, and, if necessary, an easier way to perform reconstructive surgeries.[4]

Implant removal is not a procedure without risks and complications, so its indication should be discussed with those responsible preoperatively. During removal, there is a risk of damage to neurovascular structures, broken screws, impossibility of complete material removal, need to enlarge the initial incision or make new ones, evolution with superficial or deep infection, and increased risk of refracture.[3] The risk of complications associated with implant removal reported in the literature is approximately 10%.[5]

There is no evidence in the current literature to fully support or refute routine implant removal in children. Therefore, the study of implant removal is interesting due to its impact on orthopedic practices and health care costs.[3]

This study aims to analyze postoperative complications in implant removal of pediatric patients, correlating them with epidemiological factors and type of removed implant.

Materials and Methods

This is a retrospective cross-sectional study, based on medical records and imaging exams from a tertiary hospital, from February 2021 to June 2024.

This study was submitted to the Research Ethics Committee and approved under the number CAAE: 83355224.6.0000.5225.

Patients under 18-years-old who underwent surgery for implant removal were analyzed. They were followed up until outpatient discharge and had their medical records fully completed, with a sample estimate of 350 patients.

Those who had exposed hardware, who underwent outpatient implant removal, those with incomplete medical records, and those who lost postoperative follow-up, were excluded.

The variables collected for analysis were age, sex, type of implant used, surgical indication for insertion (trauma vs. orthopedic disease), implant insertion site (upper vs. lower limb), indication for removal, time to implant removal, and complications related to removal.

Postoperative complications related to implant removal were considered in this study: failure to remove the implant,

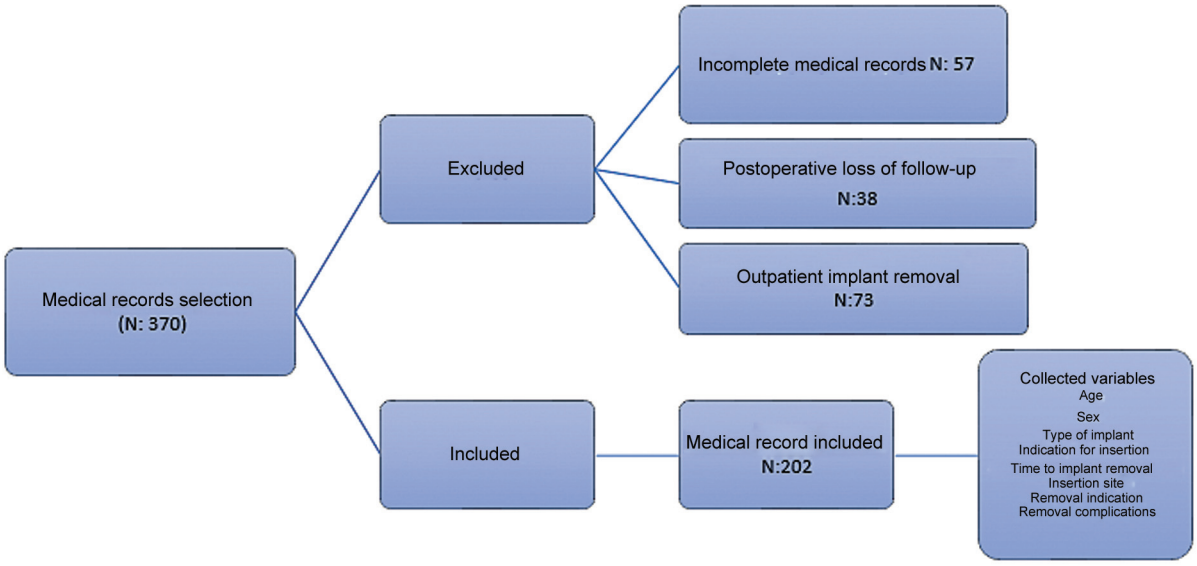


Fig. 1 Flowchart of the selection of patients' medical records.

refractures, limitation of range of motion in the postoperative period, and superficial surgical wound infections.

For the analysis of the postoperative complications, the Clavien-Dindo classification (CDC) was used.[6,7] In type I, any deviation from the ideal postoperative course without the need for pharmacological treatment or surgical and/or radiological interventions. Type II patients require pharmacological treatment with drugs other than those allowed for type I complications. Type III requires surgical and/or radiological intervention, divided into (a) without and (b) with general anesthesia. Type IV refers to life-threatening complications, including (a) single and (b) multiple organ dysfunction. Finally, type V refers to patient death.[7]

Data were quantitatively analyzed using Microsoft Excel 2010 (Microsoft Corp.) for absolute and relative frequency measurements. Comparisons between variables were performed using the Chi-squared test for quantitative variables. The statistical analyses were conducted in the R program (RStudio, 2020), and p-values < 0.05 were considered significant.

Results

There were 370 medical records selected, with patients aged 0 to 18 years who underwent implant removal between February 2021 and June 2024. After applying the exclusion criteria, 202 were included in the sample analyzed (►**Fig. 1**).

Of the 202 patients in the sample, 156 (77.2%) were male and 46 (22.8%) were female. The mean age of the sample was 11.5 years, ranging from 4 to 17 years. In males, the mean age was 11.7 years; in females, 10.8 years.

The mean time to implant removal was 9.7 months, ranging from 1 to 72 months. ►**Table 1** shows the mean time to implant removal in patients who presented complications (14.4 months) versus those who did not (10.3 months).

Table 1 Evolution time (months) according to complication in 202 patients

Complications	Mean evolution (months)	SD	*p*-value
No (n = 180)	10.3	9.0	0.846
Yes (n = 22)	14.4	16.7	

Abbreviation: SD, standard deviation.

Table 2 Time to implant removal according to the type of material inserted in 202 patients

Type of material inserted*	Mean time to implant removal (months)	SD
KW (n = 62)	6.5	5.6
External fixator (n = 17)	4.6	3.1
Intramedullary nails (n = 70)	11.0	6.8
Screw (n = 8)	14.3	11.5
Plate (n = 41)	18.5	15.8

Abbreviations: KW, Kirschner wires; SD, standard deviation.
Note: *Patients who had more than one type were removed.

Of the implants removed, 62 were Kirschner wires (intramedullary for forearm fracture fixation or transosseous fixation left buried subcutaneously), 70 flexible intramedullary nails, 17 external fixators, 41 plates and screws, and 8 isolated screws. The mean implant retention time until removal, in months, is shown in ►**Table 2**.

The reason for implant removal in 83.6% (n = 169) of the patients was due to bone consolidation, discomfort and/or prominence related to the implant in 8.98% (18), having achieved the desired limb alignment (post-, hemi-, or epiphysiodesis) in 3.46% (n = 7), limitation of range of motion

Table 3 Presence or absence of complications according to different qualitative variables in 202 patients

Variable	Categories	Complications (%)		*p*-value
		No (n = 180)	Yes (n = 22)	
Sex	Female (n = 46)	87	13	0.595
	Male (n = 156)	90	10	
Implant*	KW (n = 62)	92	8	0.867
	External fixator (n = 17)	88	12	
	Flexible nails (n = 70)	90	10	
	Screw (n = 7)	86	14	
	Plate (n = 41)	85	15	
Reason for insertion	Disease (n = 24)	83	17	0.307
	Trauma (n = 178)	90	10	
Site of trauma	Lower limb (n = 100)	88	12	0.659
	Upper limb (n = 101)	90	10	

Abbreviation: KW, Kirschner wires.
Note: *Patients who had more than one category were removed.

related to the implant in 1.98% (n = 4), exposure of the material in 1.48% (n = 3), and due to superficial infection related to the implant in 0.5% (n = 1).

Complications were reported in 11% (n = 22), among which 36.5% were superficial infection (8/22), 9% of temporary range of motion limitation after removal that recovered in outpatient follow-up (2/22), 9% of refractures (2/22), and 45.5% of failure in total implant removal (10/22), which was the most frequent one. There was a 10% rate in male and 13% in female patients.

Analyzing the complications related to the type of implant removed, 8% were in Kirschner wires (5/62 withdrawals), 12% in external fixators (1/17), 10% in flexible intramedullary nails (7/70), 14% in isolated screws (2/8), and 15% in plates and screws (7/41).

Regarding the indication for implant insertion, 24 were due to orthopedic disease, among whom 17% (n = 4), and 178 were patients with a traumatic incident, among whom 10% (n = 18) experienced complications.

Regarding the sites of implant removal, 100 were in the lower limb and 101 in the upper limb, with complication rates of 12 and 10%, respectively. The data analyzed of the total sample are shown in ►**Table 3**.

Considering the sample only of patients who had complications (►**Table 4**), the mean age was 12 (6–17) years, the mean time to removal was 16 (2–72) months. Furthermore, 50% (11–22) occurred in the upper limbs, and 50% (11–22) in the lower ones.

Analyzing the anatomical site in which the complications occurred: 7 implants were removed from the thigh, 6 from the forearm, 2 from the elbow, 2 from the shoulder, 1 from the hip, 1 from the knee, 1 from the leg, 1 from the foot, and 1 from the elbow.

Regarding the type of implant among cases with complications, there were 31.8% (n = 7) with flexible nails, 31.8% (n = 7) plates, 22.9% (n = 5) Kirchner wires, 9.0% (n = 2) isolated screws, and 4.5% (n = 1) with external fixators.

Analyzing the reason for implant removal, 73% (n = 16) were due to bone consolidation, 9% (n = 2) implant exposure, 4.5% (n = 1) limited range of motion, 4.5% (n = 1) implant discomfort, and 4.5% (n = 1) local superficial infection.

Using the CDC,[6,7] there were 10 type I complications (45.45%), 9 type II (40.9%), and 3 type IIIa (13.6%), as shown in ►**Table 5**.

Discussion

Implant removal is a relatively common procedure in pediatric orthopedics, especially when there are signs of infection, the implant causes discomfort, or it may alter bone growth.[4]

Depending on the implant site, permanence may make future procedures difficult.[8] The advantages and disadvantages of removing implants in children are discussed, so studying the possible complications of these procedures may assist in decision-making.[4]

The study by AlOmran et al.,[1] evaluated the routine implant removal in 167 patients, with a complication rate of 6%. Similarly, the study by Desai et al.[8] found a 9.5% complication rate after analyzing 2,176 cases. In our series, after evaluating 202 cases, we found an overall complication rate of 11%, which is consistent with the literature.

Also, according to Desai et al.,[8] implant removal after a long time since insertion is associated with a higher risk of complications, especially incomplete removal or material breakage. In these situations, the implant may be covered by a bony callus that forms over time, prolonging the time required for its removal and potentially leading to incomplete removal, making the procedure more invasive and increasing the risk of complications.[4,9]

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Table 4 Postoperative complications after implant removal grouped according to epidemiological characteristics evaluated

Sex	Age (years)	Inserted material	Reason for insertion	Surgical site	Time to removal (months)	Reason for removal	Complications
F	6	Intramedullary nails	Femoral diaphyseal fractures	Thigh	7	Consolidation	Infection SW
M	9	Intramedullary nails	Femoral diaphyseal fractures	Thigh	8	Infection SW	Restricted ROM
M	9	Plate 2.7mm	Right hallux arthrodesis	Feet	10	Consolidation	Infection SW
M	9	Cancellous screw 3.5mm + washer	Pseudarthrosis of the lateral condyle	Elbow	7	ROM limitation	Unsuccessful removal
F	10	Angled hip plate	Paralytic hip dislocation	Hip	72	Exposed hardware	Infection SW
F	10	Dynamic compression plate 4.5mm	Distal tibial fracture	Leg	12	Consolidation	Unsuccessful removal
F	11	External fixator	Distal femoral fracture	Thigh	7	Consolidation	Refracture
M	11	Dynamic compression plate 4.5mm	Subtrochanteric fracture	Thigh	12	Consolidation	Unsuccessful removal
M	11	Intramedullary nails	Femoral diaphyseal fractures	Thigh	7	Consolidation	Infection SW
M	11	KW	Forearm fracture	Forearm	6	Consolidation	Infection SW
M	12	KW	Forearm fracture	Forearm	2	Exposed hardware	Infection SW
M	13	KW	Forearm fracture	Forearm	5	Consolidation	Restricted ROM
M	13	DCP 4.5mm	Diaphyseal fractures of the radius	Wrist	14	Consolidation	Unsuccessful removal
M	13	Intramedullary nails	Femoral diaphyseal fractures	Thigh	24	Consolidation	Unsuccessful removal
M	13	KW	Forearm fracture	Forearm	6	Consolidation	Infection SW
F	14	Cannulated screw 3.0	Medial epicondyle fracture	Elbow	31	Consolidation	Unsuccessful removal
M	14	DCP 4.5mm	Femoral diaphyseal fractures	Thigh	53	Consolidation	Unsuccessful removal
F	14	Intramedullary nails	Humerus diaphyseal fractures	Shoulder	10	Consolidation	Unsuccessful removal
M	14	KW	Forearm fracture	Forearm	5	Consolidation	Refracture
M	15	Intramedullary nails	Proximal humerus fractures	Shoulder	16	Material discomfort	Unsuccessful removal
M	15	Plate in 8	Limb-length discrepancy	Knee	12	Alignment	Infection SW
M	17	Intramedullary nails	Forearm fracture	Forearm	24	Consolidation	Unsuccessful removal

Abbreviations: DCP, dynamic compression plate; KW, Kirschner wires; ROM, range of motion; SW, surgical wound; TEM,.

Table 5 Postoperative complications after implant removal grouped accordingly to Clavien-Dindo classification

Type	N (%)
I	10 (45.45%)
II	9 (40.9%)
IIIa	3 (13.6%)
IIIb	0 (0)
IV	0 (0)
V	0 (0)

The higher complication rate in our study is associated with implant removal failures. In our sample, the mean time to removal in cases of complications was 16 months, which is lower than the mean reported in the literature.

Among implants with incomplete removal, 2 flexible nails used to treat humeral fractures were not removed due to the corkscrew effect, 1 in the femur and 1 in the forearm, due to attempts to remove them being performed 16 months postoperatively. Among the cases of isolated screw removal, the screw broke in 2, allowing only partial implant removal. In the 4 cases of screws used in plate fixation, we were successful in removing the plate, but some screws broke, resulting in incomplete removal.

Implant insertion usually occurs with a minimally invasive approach. However, removal surgery can often be challenging, requiring a larger incision than the initial one, which can lead to a higher rate of complications, such as infections in postoperative wounds.[5]

Postoperative infection was the second most frequent complication in our sample. The infections were superficial, clinically treated with antibiotics, without the need for additional surgical procedures.

In our study, we observed 2 cases of refractures that occurred after removal of the intramedullary Kirschner wire used for forearm fixation, and another after removal of a Limb Reconstruction System (LRS) external fixator to treat an infected femoral pseudarthrosis, with a permanence of 5 and 7 months, respectively. These cases may be related to insufficient bony callus formation, and patients underwent additional surgical procedures to treat this complication. Therefore, the indication for removal should occur after the bony callus is formed and the medullary canal is completely remodeled, to avoid the risk of refracture after removal.[4]

Scheider et al.[10] evaluated the risk of complications associated with removal of upper limb implants in a hospital setting, there were 449 cases with an overall complication rate of 17.1%, and a mean time to implant removal of 23.7 months.

The risk of complications does not seem to be the same across all body sites, with cases in the upper limb being less common.[5] In our study, a similar pattern of upper and lower limb removals was observed, with no statistically significant differences in complications between limbs.

Lieber et al.[4] analyzed the removal of flexible intramedullary nails in 384 patients and found a lower complication rate of 3.1%. The technical rigor during the initial surgery directly affects the removal procedure, increasing the risk of complications with improperly placed implants. In our study, 4 nails could not be removed (2 humeral, 1 femoral, and 1 forearm fracture); 1 wound dehiscence; 1 superficial infection; and 1 patient was slow to regain knee mobility after removal.

Regarding the removal of isolated screws, the complication rate in the total sample was 14%. The study by Zimmerman et al.[9] evaluated the removal of screws used in the fixation of distal tibial fractures with deviation after 2 years of postoperative follow-up, compared with cases of implant maintenance and its long-term repercussions. Implant removal was performed in 17 patients and none had postoperative complications. Despite this finding, this study highlights that many procedures had difficulties and that they are not entirely benign, given the risks involved, requiring proper alignment with the child's family and/or caregivers.[11]

Rehm et al.[12] evaluated implant removal in femoral diaphyseal fractures and observed a risk of refracture at a mean of 11 months after the procedure. In the removal of plates and screws, no refractures occurred. We had 7 complications among 41 removals, 3 screws were broken and not removed, 3 infections, and 1 patient reported discomfort after removal.

Elective implant removal should be considered, observing the risks and benefits involved with the procedure, due to its high cost potential neurovascular damage, implant breakage, infection, new or refractory complex regional pain syndrome, among other possible negative outcomes.[5,9] Therefore, there must be consensus among the surgeon, family members, and/or caregivers regarding the real need for the indication, as well as a warning about possible complications that may arise from it.

Our study has limitations, including its retrospective design that presents a high degree of heterogeneity in the sample, with different types of materials, surgical sites, and complications. The indication for implant removal did not follow a consistent pattern, and the preference of surgeons in charge was a factor to be considered. New multicenter studies to evaluate postimplant removal complications are essential to assist the orthopedic community in better decision-making.

Conclusion

Implant removal in pediatric orthopedics is not without complications, with a 11% rate being found in this study. Complete removal failure, superficial infections, and refractures were the most common ones. The procedure should consider the risks and benefits involved and require consensus among family members and surgeons. Multicenter studies are suggested to expand knowledge on this topic.

Data Availability

Data will be available upon request to the corresponding author.

Authors' Contributions

Each author contributed individually and significantly to the development of this article. MAB, ACB: data curation; formal analysis; writing – original draft. HZF: data curation; writing – review & editing. WRV, JFS: data curation; formal analysis; writing – review & editing.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Results of Total Knee Arthroplasty with Robotic Assistance*

Resultados da artroplastia total do joelho com assistência robótica

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Abstract

Objective To investigate the outcomes of total knee arthroplasty (TKA) when assisted by a robotic arm compared with the conventional approach.

Methods We conducted a retrospective cohort study including 96 patients who underwent TKA, assigned to either the robotic-assisted (RA) group or a conventional technique (CT) groups. All surgeries were performed without the use of a tourniquet and included administration of intravenous tranexamic acid. Patients were matched based on sex, age, and preoperative hemoglobin (Hb) and hematocrit (Ht) values. Key outcomes evaluated were perioperative blood loss (assessed through changes in Hb and Ht), operative duration, length of hospital stay, and postoperative complications up to 6 months.

Results There were 34 patients from each group successfully matched for analysis. There were no significant differences between the groups regarding Hb or Ht reduction (RA: Hb -2.27 ± 1.21 g/dL, Ht -6.56 ± 3.43%; vs. CT: Hb -2.00 ± 1.07 g/dL, Ht -5.85 ± 3.26%; $p > 0.05$). The mean surgical time was also similar (RA: 108.9 ± 20.8 vs. CT: 111.8 ± 26.2 min; $p = 0.905$). Notably, patients in the RA group experienced a shorter hospitalization period (median: 2 vs. 2.5 days; OR = 0.12; 95% CI = 0.03–0.57; $p = 0.008$). Incidence of postoperative complications within 6 months did not differ significantly between groups.

Conclusion Robotic-assisted TKA was not associated with measurable improvements in blood loss, operative time, or postoperative complications. However, it contributed to a reduction in hospital stay compared with the conventional technique.

Keywords
- arthroplasty
- blood loss, surgical
- knee
- robotic surgical procedures

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Resumo

Objetivo Investigar os resultados da artroplastia total do joelho (ATJ) com assistência de braço robótico em comparação com a abordagem convencional.

Métodos Realizamos um estudo de coorte retrospectivo, incluindo 96 pacientes submetidos a ATJ, que foram alocados aos grupos assistência robótica (AR) ou técnica convencional (TC). Todas as cirurgias foram realizadas sem o uso de torniquete e incluíram a administração de ácido tranexâmico intravenoso. Os pacientes foram pareados com base no sexo, na idade e nos valores pré-operatórios de hemoglobina (Hb) e hematócrito (Ht). Os principais desfechos avaliados foram a perda sanguínea perioperatória (avaliada por meio de alterações em Hb e Ht), a duração operatória, o tempo de internação hospitalar e as complicações pós-operatórias até em 6 meses.

Resultados Foram 34 pacientes para cada grupo pareados com sucesso para análise. Não houve diferenças significativas entre os grupos quanto à redução de Hb ou Ht (AR: Hb $-2{,}27 \pm 1{,}21$ g/dL, Ht $-6{,}56 \pm 3{,}43\%$; vs. TC: Hb $-2{,}00 \pm 1{,}07$ g/dL, Ht $-5{,}85 \pm 3{,}26\%$; $p > 0{,}05$). O tempo cirúrgico médio também foi semelhante (AR: $108{,}9 \pm 20{,}8$ vs. TC: $111{,}8 \pm 26{,}2$ min; $p = 0{,}905$). Notavelmente, os pacientes do grupo AR tiveram um período de hospitalização mais curto (mediana: 2 vs. 2,5 dias; OR = 0,12; IC 95% = 0,03–0,57; $p = 0{,}008$). As complicações pós-operatórias em 6 meses não diferiram significativamente entre os grupos.

Conclusão A ATJ com assistência robótica não foi associada a melhorias mensuráveis na perda sanguínea, tempo operatório ou complicações pós-operatórias. Entretanto, contribuiu para uma redução na permanência hospitalar em comparação com a técnica convencional.

Palavras-chave

- artroplastia
- joelho
- perda sanguínea cirúrgica
- procedimentos cirúrgicos robóticos

Introduction

Total knee arthroplasty (TKA) is a common surgical intervention aimed at relieving pain and restoring function in patients with severe osteoarthritis or other debilitating joint conditions.[1] This procedure involves replacing the knee joint with a prosthesis by removing damaged portions of the femur, tibia, and cartilage.[2] However, TKA is associated with significant concerns regarding bleeding, which may lead to postoperative complications, increase the risk of transfusions, and prolong patient recovery.[2]

In recent decades, the introduction of robotic arm assistance has revolutionized the precision and effectiveness of the procedure, raising important questions about its impact on bleeding levels.[3] Conventional TKA relies on preoperative radiographs, intraoperative anatomical landmarks, and manual alignment guides, whereas robotic-assisted TKA provides a virtual three-dimensional (3D) reconstruction that accounts for each patient's specific anatomy.[4,5] This enables more accurate planning of bone resections and prosthesis positioning, thereby improving tissue preservation and reducing postoperative inflammation and pain,[4,5] although no significant differences have been demonstrated in medium- and long-term functional outcomes when compared with the conventional technique.[6–10]

Additionally, other perioperative strategies, such as the use of the antifibrinolytic agent tranexamic acid, have been employed to reduce blood loss and the need for transfusions.[11] Several meta-analyses have shown that tranexamic acid is safe and significantly decreases both total and postoperative blood loss, as well as the mean number of transfusions per patient, without increasing the rate of complications.[12–14]

Tourniquets have been traditionally used in TKA, based on the belief they can reduce intraoperative bleeding and improve prosthesis cementation.[15] However, a meta-analysis published in 2021 indicated that tourniquet use may not offer significant advantages in this regard and is associated with risks, such as soft-tissue damage, greater postoperative pain, and longer hospital stay. Although it may reduce surgical time, these potential adverse effects highlight the need to reconsider its routine use.[15]

To date, there is no consensus regarding bleeding rates in robotic-assisted TKA, particularly when performed in combination with intravenous tranexamic acid and without the use of a tourniquet.[16]

The hypothesis of this study is that robotic-assisted TKA results in lower perioperative bleeding, fewer postoperative complications, and reduced surgical time when compared with the conventional surgical method.

Materials and Methods

Ethical Aspects

This study was conducted after approval by the Institutional Research Ethics Committee, CAAE number 79863824.2.0000.5696.

Study Design

This was a retrospective observational study performed through the analysis of medical records of patients who underwent TKA performed by the same knee surgery team between July 2022 and 2023. Patients were divided into two distinct groups: one in which TKA was performed with robotic-assistance and the other with the conventional method.

Inclusion criteria comprised all patients who underwent TKA without the use of a tourniquet and with administration of tranexamic acid. Exclusion criteria were revision TKA, concomitant corrective osteotomy, previous coagulation disorders, or use of anticoagulant medication within 7 days prior to surgery.

Data Collection

The following data were collected from patient medical records during hospitalization: sex, age, weight, height, previous coagulation disorders, date of surgery, surgical time, robotic-assistance, as well as use of anticoagulant medications, tranexamic acid, and tourniquet. We also collected data on intraoperative complications, need for additional procedures, preoperative and 24-hour postoperative Hb and Ht levels, length of hospital stay, and postoperative complications up to the 6th month, the latter of which included transfusions, reoperation for hematoma drainage, arthrofibrosis, wound dehiscence, superficial and deep infection, deep vein thrombosis (DVT), pulmonary embolism (PE), myocardial infarction, and death.

All patients included had blood samples collected through peripheral venipuncture in the preoperative period and at 24 hours after surgery. Surgical time for each procedure was recorded by the nursing and anesthesia teams. All patients underwent spinal anesthesia and received 1 g of intravenous tranexamic acid at induction. The medial parapatellar approach was preferred, without tourniquet use.

The implants were cemented, without patellar replacement, and with the same instrumentation. In the robotic-assisted group, the ROSA Knee System (Zimmer Biomet) was used. No suction drain was applied in any case.

Thromboprophylaxis consisted of mechanical methods using an intermittent pneumatic compression device on the calves during the first 24 hours postoperatively, along with elastic compression stockings for the first 30 days. Pharmacological prophylaxis included rivaroxaban 10 mg orally, initiated 6 hours after the procedure and maintained at the same dose every 24 hours for 10 days in all patients.

The hospital discharge criteria included hemodynamic stability, adequate pain control, and the ability to ambulate independently with a walker.

Statistical Analysis

Both Hb and Ht were considered dependent variables, while age, sex, surgical time, length of hospital stay, and complications (including death) were considered independent ones. Categorical variables were expressed as frequency and percentage, while quantitative ones were assessed for normality using the Shapiro–Wilk test. The statistical significance of qualitative variables was evaluated using Fisher's exact test, and quantitative variables were analyzed with the Student's *t* or Mann–Whitney's tests, according to data distribution.

Additionally, a multivariate regression analysis adjusted for age and sex was performed using the Wald test to determine the impact of robotic-assistance on reductions in Hb and Ht, surgical time, hospital stay, and complication rates. All analyses were performed using the Stata/SE v.16.1 (StataCorp LLC), with the significance level set at $p < 0.05$.

Results

During the study period, a total of 96 patients underwent TKA without tourniquet use and with tranexamic acid administration. Of these, 85 patients were included in the study; furthermore, 6 were excluded due to revision surgery, 2 due to associated osteotomy, and 2 due to coagulation disorders). After statistical matching of the groups, the robotic-assisted and conventional surgery groups comprised 34 patients each. The study flowchart is illustrated in ►**Fig. 1**.

►**Table 1** presents the baseline characteristics of the patients. The mean age, sex distribution, and baseline Hb and Ht levels were similar between the groups, with no statistically significant differences ($p > 0.05$).

Surgical time and length of hospital stay were also evaluated. There was no significant difference in surgical time between the groups ($p = 0.621$). However, there was a significant difference in hospital stay, with shorter lengths in the robotic-assisted group ($p = 0.008$), as shown in ►**Table 1**.

Regarding surgical complications, the results showed no statistically significant differences between the groups for any of the variables. No cases of PE, transfusion requirements, or deaths were identified (►**Table 1**).

As shown in ►**Table 2**, the differences in mean pre- and postoperative (24h) Hb and Ht levels were not statistically significant between the robotic and conventional groups.

In ►**Table 3**, the multivariate regression analysis adjusted for age and sex revealed that robotic-assistance had a significant impact only on reducing hospital stay (OR = 0.12; 95% CI = 0.03–0.57; $p = 0.008$), with no significant influence on other variables (Hb, Ht, surgical time, and complications).

Discussion

This study did not demonstrate significant differences in the reduction of Hb and Ht levels after surgery between the robotic-assisted and conventional groups ($p > 0.05$). This finding suggests that, in the absence of tourniquet use and with intravenous tranexamic acid administration, robotic-assisted TKA does not provide a clear advantage in terms of blood loss compared with the conventional technique.

These results are consistent with a retrospective study published in 2022,[16] which included 486 patients and employed both tourniquet and tranexamic acid. They also align with a systematic review and meta-analysis published in 2024,[17] which evaluated 12 studies involving 2,863 patients and analyzed transfusion requirements and blood

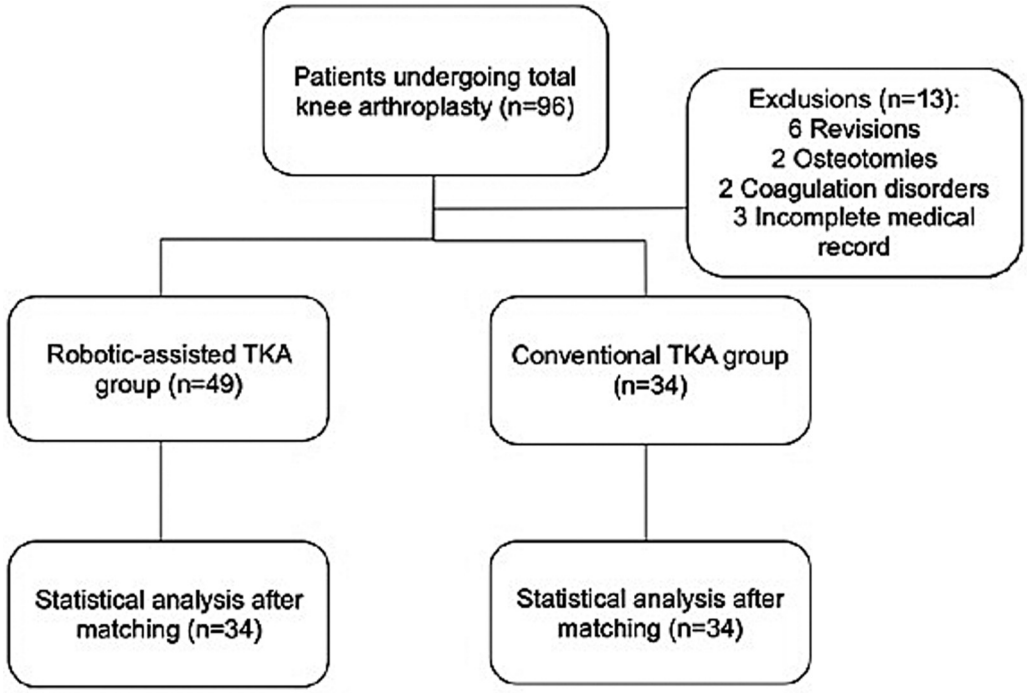


Fig. 1 Study's flowchart.

loss in conventional versus robotic-assisted TKA. However, that review did not address the use of tranexamic acid or tourniquet in the included studies.[17]

None of the patients in the present study required blood transfusion. In contrast, a retrospective cohort study by Khan et al., published in 2021, reported six cases of transfusion in the conventional group (12%) and one in the robotic-assisted group (2%), showing a statistically significant difference.[2] In their study, both tranexamic acid and a tourniquet were used in all patients.[2]

Surgical time also did not differ significantly between groups in our study. The mean duration was 108.8 ± 20.8 minutes in the robotic-assisted group versus 111.79 ± 26.17 minutes in the conventional group ($p = 0.484$). A previous randomized controlled trial reported that robotic-assisted TKA was associated with longer operative time compared

Table 1 Baseline characteristics of the patients

	Robotic-assisted ($n = 34$)	Conventional ($n = 34$)	*p*-value
Age (years)	67.8 ± 9.7	68.2 ± 7.4	0.845[a]
Males, n (%)	26 (53.1)	13 (38.2)	0.263[b]
Hb (g/dl)	13.56 ± 1.05	13.05 ± 1.31	0.079[a]
Ht (%)	40.32 ± 3.15	39.49 ± 4.19	0.358[a]
Time of surgery (min)	108.9 ± 20.8	111.79 ± 26.17	0.621[a]
Hospital stay (days)	2 (1–3)	2 (2–3)	0.008[c]
Transfusion (n)	0	0	
Superficial infection (n)	4 (11.8)	1 (2.9)	0.356[b]
Deep infection (n)	2 (5.6)	1 (2.9)	> 0.999[b]
Arthrofibrosis (n)	1 (2.9)	1 (2.9)	> 0.999[b]
Thrombosis (n)	0 (0)	1 (2.9)	> 0.999[b]
Embolism (n)		0	
Heart attack (n)	1 (2.9)	0 (0)	> 0.999[b]
Death (n)	0	0	

Abbreviations: Hb, hemoglobin; Ht, hematocrit. a Test t, b Chi-square, c Mann-Whitney test.

Table 2 Difference in means for Hb and Ht of patients undergoing TKA with and without the use of a robot in relation to the preoperative period

Time	Robotic-assisted Averages (SD)	Conventional Averages (SD)	*p*-value
Hb (mg/dl)			
24h	−2.27 (1.21)	−2.00 (1.07)	0.329
Ht (%)			
24h	−6.56 (3.43)	−5.85 (3.26)	0.383

Abbreviation: Hb, hemoglobin; Ht, hematocrit; SD, standard deviation; TKA, total knee arthroplasty.

Table 3 Effect of robot use on reducing Hb and Ht, hospitalization days, TKA time, and presence of complications*

	OR	95% CI	*p*-value
Hb Reduction	1.83	0.67–4.99	0.236
Ht Reduction	0.91	0.65–1.23	0.594
Surgery time	1.01	0.98–1.03	0.905
Hospital stay	0.12	0.03–0.57	0.008
Superficial infection (n)	0.23	0.01–4.03	0.316
Deep infection (n)	2.19	0.08–60.1	0.642
Arthrofibrosis	0.78	0.04–15.0	0.868

Abbreviation: CI, confidence interval; Hb, hemoglobin; Ht, hematocrit; OR, odds ratio; TKA, total knee arthroplasty.
Note: *Multivariate regression analysis. Wald test. Model adjusted for age and sex.

with the conventional approach,[18] whereas a descriptive qualitative study suggested that robotic-assistance should reduce surgical time.[19] Robotic technology allows for preoperative simulations, preventing errors in prosthesis positioning and assisting surgeons' decision-making.[19] However, such procedures may sometimes take longer, particularly during the initial learning curve.[20] In our study, robotic-assisted surgeries were performed within the 1st year after implementation of the system in our institution, yet no difference in surgical time was observed.

Postoperative complications classically described in TKA showed no significant differences between groups,[21–23] including transfusion, reoperation for hematoma drainage, arthrofibrosis, wound dehiscence, superficial and deep infection, DVT, PE, myocardial infarction, and death—. This is consistent with a retrospective cohort study published in 2022 analyzing a large TKA database,[24] which found no association of the increasing adoption of robotic-assisted TKA with higher rates of infectious or non-infectious complications.

Regarding infections, a retrospective study by Ofa et al.,[25] published in 2020, compared robotic-assisted and conventional TKA and found no significant difference within 90 days postoperatively. Infection rates were 0.62% in the conventional group and 0.48% in the robotic-assisted group.[25] In our study, no statistical differences were observed, but the overall infection rate was higher than reported in the literature, reaching 4% at 6 months.

In terms of DVT, our study identified one case in the conventional group and none in the robotic-assisted group, without statistical significance. A retrospective study by Itou et al., published in 2023,[26] which used both a tourniquet and tranexamic acid, also found that robotic-assisted TKA was not associated with increased postoperative DVT risk. Another retrospective consecutive case series suggested that, despite longer operative times, robotic-assisted surgery may be safer, being associated with a lower incidence of DVT.[5] This may be attributed to less soft-tissue trauma and avoidance of femoral canal violation.[5]

Furthermore, a randomized case-control study published in 2022 by Xu et al.[20] compared early clinical and radiographic outcomes of robotic-assisted versus conventional manual TKA with tourniquet use, reporting no significant differences in DVT incidence. Both studies emphasized the role of anticoagulant regimens, such as factor Xa inhibitors, in reducing postoperative DVT risk, consistent with our study protocol.[18,20,27]

We found a significant reduction in hospital stay in the robotic-assisted group (95% CI: 0.03–0.57, $p = 0.008$), indicating a potential benefit of this technology in enhancing postoperative recovery. Previous studies comparing conventional and robotic-assisted TKA have also demonstrated shorter hospitalization times.[25–28] For instance, a retrospective cohort study published in 2024 reported a mean length of stay of 1.89 days in the robotic-assisted group versus 2.41 days in the conventional group.[28] Other retrospective studies published in 2018 and 2024 also found significant reductions in hospitalization duration for robotic-assisted TKA patients.[27,28]

In our study, discharge criteria were based on hemodynamic stability, the ability to ambulate with a walker, and adequate

pain control. It is noteworthy that the comparative studies reviewed here also reported tranexamic acid use during surgery but did not provide specific discharge criteria. Furthermore, in one study,[27] a pneumatic tourniquet was used but never inflated, while another[28] did not specify its use.

This study has several limitations. The most important being its retrospective design, which may have affected the results' accuracy. Moreover, being conducted in a single center limited the sample size. On the other hand, this approach minimized bias from inter-surgeon variability in technique. Additionally, no data on functional outcomes or pain scores were collected, precluding a more comprehensive comparison.

Conclusion

In this study, the choice of surgical approach—robotic-assisted versus conventional TKA—did not result in significant differences in hemoglobin or hematocrit levels 24 hours after surgery. Similarly, operative time, the requirement for blood transfusions, and the incidence of postoperative complications were comparable between the two techniques.

Notably, patients undergoing robotic-assisted TKA had a significantly shorter hospital stay, indicating a potential advantage of this technology in promoting faster postoperative recovery and earlier discharge.

Data Availability

Data will be available upon request to the corresponding author.

Authors' Contributions

Each author contributed individually and significantly to the development of the article. JPFG: supervision, validation, visualization, writing - original draft, writing - review & editing, conceptualization, data curation, formal analysis, investigation, methodology, validation, and visualization; JCP: research incentive, validation and visualization, data curation; writing - original draft; writing - review & editing; LS: research incentive, validation and visualization, data curation; writing - original draft; writing - review & editing; TDP: research incentive, validation and visualization, data curation; writing - original draft; writing - review & editing. PRB: conceptualization, formal analysis, validation and visualization; MVD: conceptualization; research incentive, validation, writing - review & editing, and visualization.

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Conflict of Interests

The authors have no conflict of interests to declare.

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The Trifurcated Anatomy of The Upper Trunk of The Brachial Plexus: Suprascapular Nerve, Posterior Division, and Anterior Division

Anatomia da trifurcação do tronco superior do plexo braquial: Nervo supraescapular, divisão posterior e divisão anterior

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Abstract

Objective To provide a comprehensive depiction of the anatomy of the upper trunk and its distal trifurcation through the dissection of brachial plexuses obtained from adult cadavers.

Methods We dissected 40 brachial plexuses from adult cadavers preserved using a unique formalin-based technique developed and used by the Anatomy Department of our institution. Bilateral dissection was performed on 20 cadavers placed in the dorsal decubitus position with accurate arm adduction. While the primary focus was on the upper trunk's anatomy, a thorough exploration of the entire brachial plexus was achieved through an extended incision.

Results The posterior division of the upper trunk was consistently located between the suprascapular nerve and the anterior division. In 22 (55%) of the dissected brachial plexuses, the suprascapular nerve originated from the proximal region of the posterior

Keywords
- adult
- brachial plexus
- cadaver
- clavicle

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division of the upper trunk, immediately after its bifurcation. For the remaining 18 (45%), the suprascapular nerve originated directly from the upper trunk.
Conclusion The distal trifurcation of the upper trunk of the brachial plexus includes the suprascapular nerve and the posterior and anterior divisions of the upper trunk.

Resumo

Objetivo Fornecer uma descrição abrangente da anatomia do tronco superior e de sua trifurcação distal por meio da dissecção de plexos braquiais obtidos de cadáveres adultos.
Métodos Foram dissecados 40 plexos braquiais de cadáveres adultos preservados por meio de uma técnica única, baseada em formalina, desenvolvida e utilizada pelo Departamento de Anatomia de nossa instituição. A dissecção bilateral foi realizada em 20 cadáveres, colocados em decúbito dorsal, com adução precisa do braço. Apesar de o foco principal ser a anatomia do tronco superior, uma exploração completa de todo o plexo braquial foi realizada mediante uma incisão prolongada.
Resultados A divisão posterior do tronco superior situou-se consistentemente entre o nervo supraescapular e a divisão anterior. Em 22 (55%) dos plexos braquiais dissecados, o nervo supraescapular originava-se da região proximal da divisão posterior do tronco superior, imediatamente após a bifurcação. Entre os 18 (45%) restantes, o nervo supraescapular originava-se diretamente do tronco superior.
Conclusão A trifurcação distal do tronco superior do plexo braquial inclui o nervo supraescapular e as divisões posterior e anterior do tronco superior.

Palavras-chave
- adulto
- cadáver
- clavícula
- plexo braquial

Introduction

The interscalene triangle is a conduit for the subclavian artery and brachial plexus, with the subclavian vein following an anterior course outside this triangular space. The vein is enveloped by a fascial sheath, comprising portions of the deep cervical and clavipectoral fascia.[1] Originating from the ventral branch of the inferior cervical spinal nerves and the first thoracic spinal nerve, the brachial plexus emerges from the spinal cord through ventral and dorsal roots and rootlets. As it exits the intervertebral foramen, the spinal nerve generates a recurrent meningeal branch known as *Luschka's nerve*, along with a dorsal branch responsible for the sensorimotor innervation of the posterior neck region. Furthermore, a ventral branch contributes to the constitution of the brachial plexus.[2–4]

The brachial plexus may receive contributions from the fourth cervical spinal nerve (C4; prefixed) or the second thoracic spinal nerve (T2; postfixed). The literature indicates a considerable variability in the prevalence of C4 or T2 contributions, with 67 to 75% considered typical for brachial plexuses. Among these, 17.5 to 48% are classified as *prefixed*, and 2 to 7.5% are categorized as *postfixed*.[5–8] The upper trunk forms through the fusion of the roots from C5 to C6 the middle trunk consists exclusively of the C7 root, and the lower trunk, from the union of the roots from C8 to T1. Each trunk gives rise to anterior and posterior divisions. The posterior divisions converge to create the posterior cord. In contrast, the anterior divisions of the upper and middle trunk combine to form the lateral cord, while the anterior division of the lower trunk continues to develop the medial cord.[9–11] In cases of upper trunk paralysis or traumatic injuries, a potential reconstructive approach involves using the single available root to reinnervate the deltoid through the posterior division of the upper trunk. Nerve transfers can be employed to restore elbow flexion. However, placing nerve grafts incorrectly from the single available root into the anterior division of the upper trunk and using distal-nerve transfers for elbow flexion may lead to suboptimal deltoid reinnervation due to the absence of intraplexal axons in the posterior division. Understanding this is crucial to avoid grafting into the wrong division.[12]

Describing the anatomy of the brachial plexus remains a formidable task, given its inherent complexity and the prevalence of anatomical variations.[3,9] In 1904, Dr. Wilfred Harris, a pioneering professor in the inaugural Neurology Department of a university hospital, authored an article titled "The True Form of the Brachial Plexus, and its Motor Distribution."[13] He argued that the posterior division of the upper trunk of the brachial plexus consistently originated between the suprascapular nerve and the anterior division of the brachial plexus (►**Fig. 1A**), contrary to most contemporary depictions and descriptions (►**Fig. 1B**).[12,14–16] The existing incongruence in anatomical understanding prompted us to undertake the current cadaveric dissection study to elucidate the anatomy of the upper trunk of the brachial plexus and its divisions.

Materials and Methods

The present study encompassed the dissection of 40 brachial plexuses from adult cadavers preserved using a

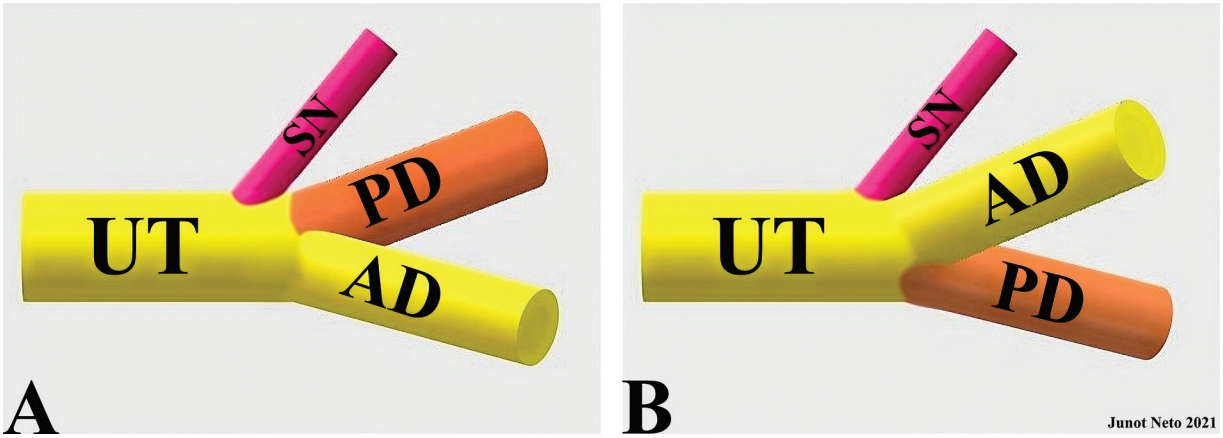


Fig. 1 Upper segment of the brachial plexus (**A**) Anatomy of the upper trunk observed in cadaveric dissections. (**B**) Upper trunk anatomy commonly presented in various literature sources. **Abbreviations:** AD, anterior division; PD, posterior division; SN, suprascapular nerve; UT, upper trunk.

light formalin-based technique developed and employed by the Anatomy Department of our institution. A bilateral examination was performed in 20 cases, all of male subjects aged 30 to 50. Cadavers showing any signs of injuries or suspected damage to the brachial plexus were intentionally excluded from the study. Fortunately, none of the dissected cadavers exhibited apparent brachial plexus injuries.

The dissections were conducted to elucidate the origins of the anterior and posterior divisions of the upper trunk of the brachial plexus and their relationship with the suprascapular nerve. The cadavers were positioned in dorsal decubitus with the arm adducted to maintain proper anatomical orientation. While the primary focus was on the anatomy of the upper trunk and its divisions, a comprehensive exposure of the entire brachial plexus in all investigated cadavers was achieved through an extended incision. This involved a longitudinal supraclavicular approach along the sternomastoid border, supplemented by a transverse supraclavicular incision over the clavicle, extending inferiorly along the deltopectoral groove.

The dissection of the supraclavicular plexus commenced with a deep incision in the skin, dividing the platysma. Subsequently, the supraclavicular nerves were identified beneath the platysma, and the deep fascia was incised along the specified line. In some instances, the fibers of the clavicular head of the sternomastoid muscle were dissected distally. Following this step, the omohyoid muscle was divided, and the fascial layer covering the scalene muscle was incised to expose the brachial plexus. An incision was meticulously made through the skin, subcutaneous tissue, and clavipectoral fascia to access the infraclavicular plexus, extending down to the clavicle. Subsequently, the tendon of the pectoralis minor muscle was located, elevated, and incised to reveal the complete length of the infraclavicular plexus. In every case, clavicle osteotomy was performed to optimize exposure. The anatomy of the upper trunk of the brachial plexus in all dissected cadavers was thoroughly documented using photographs, illustrations, and comprehensive written descriptions. These records were compiled for subsequent analysis.

The study was approved by the Plataforma Brasil ethics committee under CAAE number 95856618.6.0000.5259.

Results

A consistent anatomical pattern was observed across all 40 dissected brachial plexuses from the 20 cadavers. The posterior division of the upper trunk consistently occupied the most cranial position, originating cranially and dorsally just beneath the suprascapular nerve. Following this, the anterior division of the upper trunk assumed the most caudal position within the upper trunk of the brachial plexus, with caudal and ventral origins. Notably, the posterior division of the upper trunk was consistently located between the suprascapular nerve and the anterior division (►**Fig. 2**).

Additionally, the origin of the suprascapular nerve displayed two distinct patterns. In 22 out of the 40 dissected brachial plexuses (55%), the suprascapular nerve was found to emerge from the proximal region of the posterior division of the upper trunk, immediately after its bifurcation. Conversely, in the remaining 18 cases (45%), the suprascapular nerve originated directly from the upper trunk.

Discussion

Describing the human brachial plexus through text or illustrations has proven to be an enduring challenge, despite centuries of anatomical studies. The intricacies arise from the complex interconnections within the plexus and the documented prevalence of anatomical variations in the literature.[3,9] Many authors replicate familiar brachial plexus illustrations without thoroughly examining the spatial relationships of their constituent structures0. Such descriptions often confine themselves to recognized interconnections, assuming these depictions provide a sufficient framework

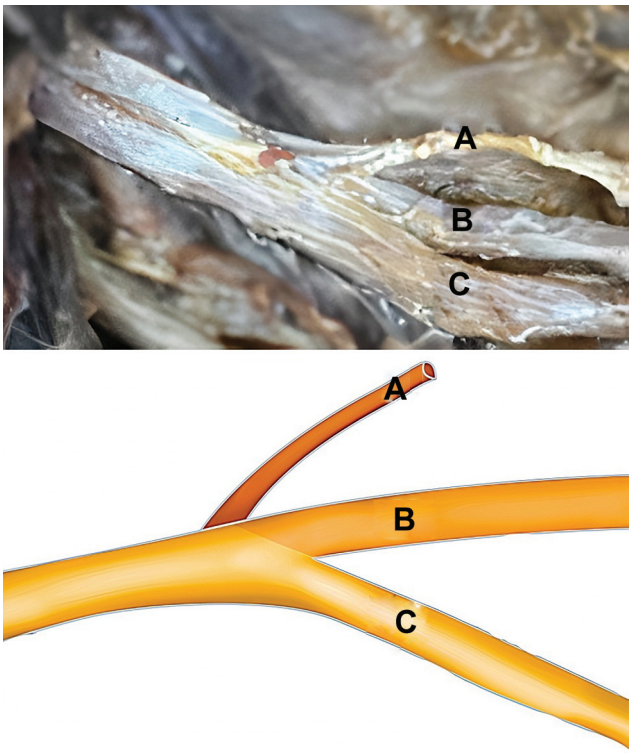


Fig. 2 Upper-trunk anatomy based on cadaveric dissections. (**A**) The suprascapular nerve is positioned more cranially. (**B**) The posterior division originates cranially and dorsally, situated between the suprascapular nerve and the anterior division of the upper trunk. (**C**) The anterior division is the most caudal structure with a caudal and ventral origin.

for understanding these connections. Hanna[14] points out that, for simplicity or convenience, the brachial plexus is frequently illustrated with the anterior division of the upper trunk positioned more cranially than the posterior division (►**Fig. 1B**). Hanna[14] suggests that this convention likely dates to Andreas Vesalius, in 1555, and acknowledges that this portrayal might perpetuate a myth since, in practice, many peripheral nerve surgeons know that the accurate arrangement is not commonly publicized in most books and scientific articles (►**Fig. 1B**).

Remarkably, Leonardo da Vinci, primarily renowned as a painter, made significant contributions to human anatomy during the sixteenth century. Under the guidance of Andrea del Verrocchio, Da Vinci embarked on anatomical endeavors involving the dissection of cadavers and the creation of numerous notes and illustrations. Da Vinci's proficiency in dissection, meticulous artistic renderings, and remarkable anatomical insights earned him acclaim. Among his notable achievements was the dissection and depiction of the brachial plexus. Interestingly, Da Vinci's illustrations portray the posterior division of the upper trunk with a cranial origin, while the anterior division of the upper trunk has a caudal origin[17] (►**Fig. 1A**).

The initial acknowledgment of an inaccurate description of the anatomy of the brachial plexus can be traced to Harris,[13] in 1904, who concluded that the posterior division of the upper trunk had a cranial origin relative to the anterior division. He asserted that the posterior division consistently resided between the suprascapular nerve and the anterior division (►**Fig. 1A**), emphasizing a deviation from the anatomy commonly published in the books and articles of his era (►**Fig. 1B**). In 2016, Hanna[14] also stated this, highlighting the distal trifurcation of the upper trunk of the brachial plexus, arranged from cranial to caudal as the suprascapular nerve, the posterior division, and the anterior division. Hanna[14] termed this arrangement the *SPA arrangement*, in which 'S' denotes the suprascapular nerve, 'P' represents the posterior division, and 'A', the anterior division (►**Fig. 1A**).

In 2015, Leung et al.[12] suggested that trauma might impact the arrangement of divisions within the upper trunk. To investigate this, they dissected 16 plexuses from fresh cadavers. Contrary to their initial hypothesis, Leung et al.[12] discovered that the suprascapular nerve consistently occupied the most lateral position within the upper trunk. Following the suprascapular nerve, the posterior and anterior divisions formed a trifurcation, with the posterior division consistently positioned between the suprascapular nerve and the anterior division (►**Fig. 1A**). Neto et al.[15] reached a similar conclusion, observing that the upper trunk of the brachial plexus displayed a distal trifurcation. From cranial to caudal, the upper trunk included the suprascapular nerve and the posterior and anterior divisions. Once again, the posterior division consistently occupied the space between the suprascapular nerve and the anterior division (►**Fig. 1A**). Neto et al.[15] illustrated a brachial plexus resembling the one shown in ►**Fig. 3**.

Arad et al.[16] reported that, in 61% of dissected brachial plexuses, the suprascapular nerve originated from the posterior division of the upper trunk. In comparison, in 35% of the cases, it originated directly from the upper trunk. Only 4% of cases showed the suprascapular nerve originating from the root of C5. Notably, our findings revealed that the suprascapular nerve emerged from the posterior division immediately after its origin in 22 (55%) cases, with 18 (45%) originating directly from the upper trunk. None of the dissected plexuses had the suprascapular nerve arising from the root of C5. In alignment with Arad et al.,[16] we agree that determining the precise origin of the suprascapular nerve can be challenging due to its proximity to the bifurcation point of the upper trunk and the multiple layers of mesoneurium surrounding the nerve. Importantly, when Arad et al.[16] concluded that the suprascapular nerve commonly originated from the posterior division, they acknowledged that the posterior division of the upper trunk of the brachial plexus had a cranial origin compared with its anterior division (►**Fig. 1A**). This observation underscores that the upper trunk of the brachial plexus and its branches manifest differently in surgery than what is typically described in most anatomy books.

Conclusion

The upper trunk of the brachial plexus displays a consistent and distinct distal trifurcation known as the *SPA*

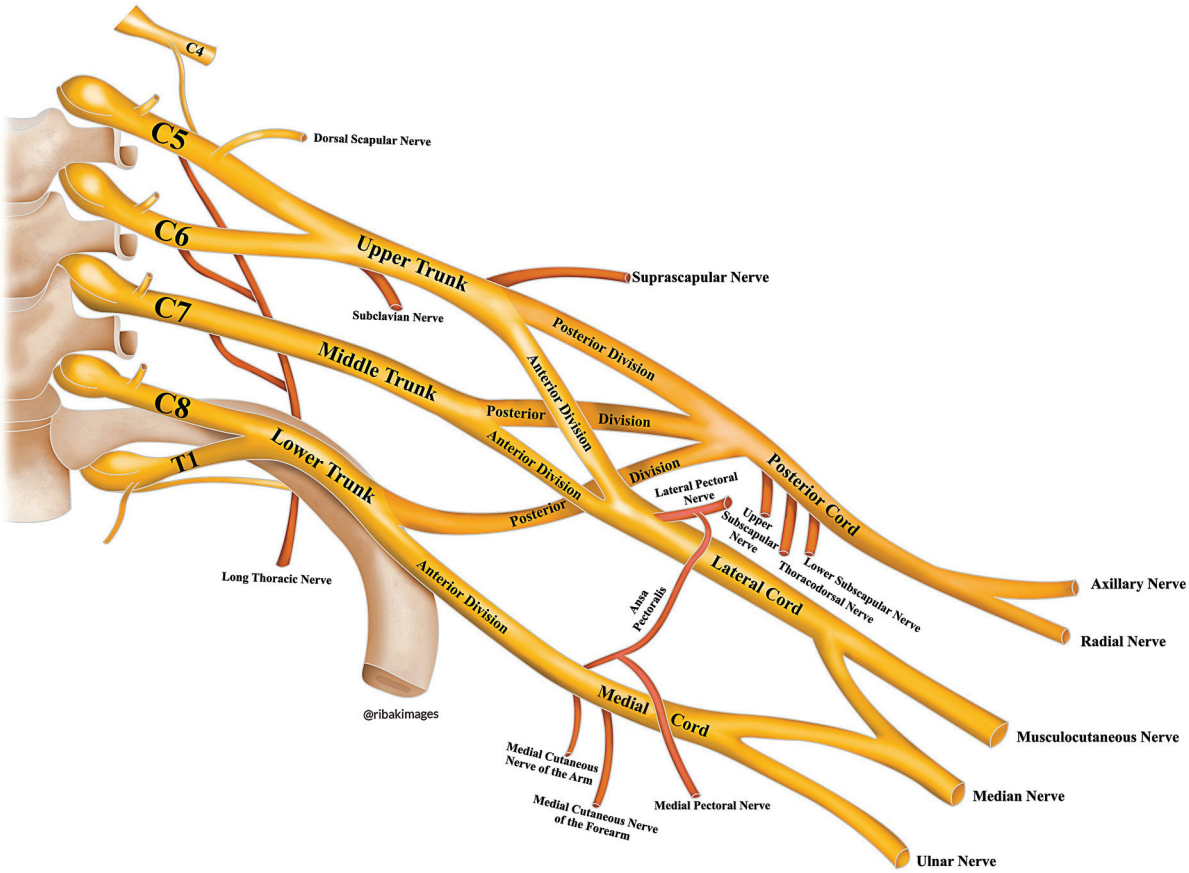


Fig. 3 Illustration of the brachial plexus according to the findings proposed by Neto et al.[15]

arrangement, as outlined by Hanna.[14] In this arrangement, from cranial to caudal, the upper trunk includes the suprascapular nerve and the posterior and anterior divisions of the upper trunk. Upon examination, 22 (55%) cases revealed the suprascapular nerve originating from the posterior division of the upper trunk, immediately after its origin. In the remaining 18 (45%) cases, the suprascapular nerve was found to derive directly from the upper trunk.

Data Availability

Data will be available upon request to the corresponding author.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Loss of Radial Height in Patients Undergoing Fixation with a Distal Volar Anatomical Locking Plate: A Retrospective Study in a Public Institution

Perda de altura radial em pacientes submetidos à fixação com placa bloqueada anatômica volar de rádio distal: Um estudo retrospectivo em uma instituição pública

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Abstract

Objective To evaluate and quantify the frequency and magnitude of late loss of radiographic parameters following volar locking plate fixation of distal radius fractures.

Methods The present is a retrospective, cross-sectional study that radiographically analyzed 65 wrists operated on between 2020 and 2024 at a public institution, evaluating postoperative loss of radial height.

Results The results showed a median loss of 0.60 mm, with 13.8% of patients experiencing losses greater than 2 mm, and 75.4% experiencing lower losses. No evidence was found that sex statistically significantly affects this incidence after the Wald test.

Conclusion Despite the effectiveness of the volar locking plate in maintaining reduction, loss of radial height still occurs, especially in older patients with more complex fractures. The present study corroborates the use of this osteosynthesis technique, a fundamental tool in the management of complex fractures of the distal third of the radius, to restore and maintain the anatomy of the region.

Keywords
- bone plates
- fracture fixation, internal
- radius fracture, distal

* *Work developed at Instituto Nacional de Traumatologia e Ortopedia, Rio de Janeiro, RJ, Brazil.*

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Resumo

Objetivo Avaliar e quantificar a frequência e magnitude da perda tardia de parâmetros radiográficos de redução de fraturas de rádio distal em pacientes operados com placa volar bloqueada.

Métodos Este é um estudo retrospectivo e transversal que analisou radiograficamente 65 punhos operados entre 2020 e 2024 em uma instituição pública, avaliando a perda de altura radial no seguimento pós-operatório.

Resultados Os resultados mostraram uma perda mediana de 0,60 mm, com 13,8% dos pacientes apresentando perdas superiores a 2 mm e 75,4% perdas inferiores. Não encontramos indícios de que o sexo do paciente afete de forma estatisticamente significativa essa incidência após o teste de Wald

Conclusão Apesar da eficácia da placa volar bloqueada na manutenção da redução, a perda de altura radial ainda ocorre, especialmente em pacientes mais idosos e com fraturas mais complexas. O presente estudo corrobora a utilização dessa técnica de osteossíntese que mostra-se uma ferramenta fundamental na abordagem das complexas fraturas do terço distal do rádio, a fim de restaurar e manter a anatomia da região.

Palavras-chave

- fixação interna de fraturas
- fraturas distais do rádio
- placas ósseas

Introduction

Distal radius fractures are the most frequent among those of the upper limbs, corresponding to 17% of all skeletal fractures and 75% of forearm fractures.[1] They have a bimodal distribution, in young people through high-energy trauma, and in the older population with low-energy trauma.[2] In recent years, an increase in distal radius fractures has been observed, mainly as a result of population aging, with them being the second most common type of fracture in this age group.[3]

Specific fracture analysis and treatment planning require knowledge of the region's normal anatomy.[4] The distal end of the radius is part of the wrist joint along with the distal end of the ulna and carpal bones, with an anatomical and biomechanical balance between the bone, muscle tendon, and ligament structures that allow for hand functionality.[5]

The distal end of the radius has a complex anatomy, with concavities and angulations in different planes. It has three concave articular facets: the scaphoid and lunate fossae and sigmoid notch, where it articulates with the scaphoid, lunate, and head of the ulna, respectively. The lunate fossa is critical to the stability of the radiocarpal and radioulnar joints and involves bone and ligament relationships.[5] The dorsal aspect of the distal end of the radius features the Lister tubercle, a bony prominence that can range from 4 to 10 mm and acts as a fulcrum for the extensor pollicis longus tendon.[6]

The distal end of the radius has inclinations and measurements that are evaluated on radiographs in neutral posteroanterior (PA) (radial inclination, radial height, and ulnar variance) and profile (volar inclination or tilt) incidences (►**Fig. 1**).

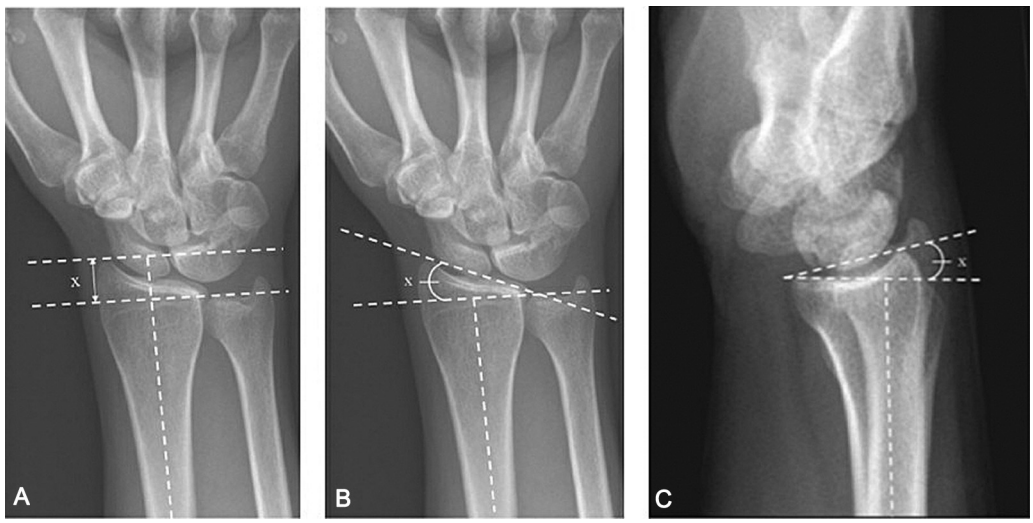


Fig. 1 (**A**) Mean radial height (X) is 11 to 12 mm. (**B**) Mean radial inclination (X) is 22 to 23º. (**C**) The volar tilt (X) is 11 to 22º. (From Patel SP, Rozental TR. Distal radius fractures: biomechanics and classification. Hand Surgery Update VI. © 2016 American Society for Surgery of the Hand).

The radial inclination is the angle between a line tangent to the articular surface of the radius, from the top of the radial styloid to the ulnar corner of the radius, and another line perpendicular to the longitudinal axis of the radius shaft, with a mean of 23 degrees.[4]

The radial height, used in the evaluation of radius shortening after fracture, can be obtained by a radiograph in PA incidence. Two lines are drawn perpendicular to the long axis of the radius, one at the tip of the radial styloid and the second at the ulnar corner of the distal radial articular surface; their normal value is about 11 to 12 mm.[7]

The ulnar variance is evaluated by a line tangent to the subchondral surface of the radiolunate joint and another tangent to the most distal portion of the articular surface of the ulna, with a mean of 1 mm.[8]

The radial volar tilt is the angle formed between a line that touches the volar and dorsal lips of the lunate fossa and another line perpendicular to the longitudinal axis of the radius, with a mean of 11 degrees.[4]

Evaluating these parameters radiologically has proven to be a reliable and reproducible method.[9]

These radiographic parameters are fundamental to evaluate the correct anatomical and functional restoration of the distal third of the radius after fractures and their respective surgical reconstructions.[10]

Distal radius fractures present with a wide range of patterns, and when surgical treatment is required, although several techniques have already been described, open reduction and internal fixation with a locking volar plate has become the method of choice.[11] The locking volar plate technique enables placement of screws in a subchondral position, providing joint surface support and reducing loss of reduction in fractures with dorsal comminution.[12]

The application of locking plates on the volar surface of the radius allowed stable fixation of intra- and extra-articular fractures, enabling early wrist mobilization and faster joint functional recovery, with superior results compared to non-locking plates, both volar and dorsal.[13] Despite this, they have complication rates ranging from 3 to 36%, according to the literature,[14] with loss of reduction being the most significant among the possible complications.[15]

There is a consensus among surgeons that the best postoperative results are obtained by reestablishing preoperative radiographic anatomical parameters. Loss of postoperative reduction, especially of radial height, is a complication that can lead to pain, instability, and loss of strength.[16]

The present study aims primarily to evaluate and quantify the frequency and magnitude of late loss of radiographic parameters following volar locking plate fixation of distal radius fractures. Secondly, we aim to correlate the radiographic parameters with the patients' chronology and epidemiological data.

Materials and Methods

The present study is a retrospective and cross-sectional analysis, approved by the Research Ethics Committee CAAE: 82364524.2.0000.5273, of patients with distal radius fractures who underwent osteosynthesis in our service between 2020 and 2024. The anatomical volar locking distal radius plate APTUS wort 2.5 (Medartis) was used as an implant.

The inclusion criteria were patients undergoing distal radius surgery with APTUS wort 2.5, minimum follow-up of 3 months, and patients over the age of 18 years.

The exclusion criteria were patients with associated fractures in the same limb, use of synthetic material in addition to the locking plate, and patients without a postoperative radiographic record available in the digital imaging system.

Patients with a time interval of up to four weeks between fracture and surgery were evaluated in the present study.

Through the digital filter "FRACTURE OF THE DISTAL END OF THE RADIUS/ FRACTURE OF THE FOREARM", the wrists operated in our service were selected during the established period. After radiographic and medical record evaluation, 114 wrists were selected for the study.

The radiographs used are standardized by the institution. In the current study, we used the true AP incidence, 1 m away from the book, 44 kilovolts (KV), and 3.2 milliamperes per second (mA/s).

Radial height was measured on the first postoperative radiograph and on subsequent postoperative radiographs using the institution's digital imaging system (►**Figs. 2**–**3**). Data such as sex, age, fracture laterality, and date of surgery were also collected. The data obtained were input into a spreadsheet and the measurements were performed by four evaluators.

Postoperative patients with distal radius fractures return at 3 weeks, 3 months, 6 months, and 1 year as a follow-up protocol. For the present study, we recruited patients with at least 2 radiographs within the past 3 months.

To standardize the evaluation, the incongruity, displacement, energy, age, and lesions (IDEAL) classification system was used, which analyzes five variables. For each one of them, a score of 0 to 1 is assigned based on the presence or absence of the factors, totaling 5 points, with type I being from 0 to 1 point; type II from 2 to 3 points, and type III from 4 to 5 points.

To score 0 or 1, the parameters according to ►**Table 1** were used.

Statistical analysis

The variation in radial height relative to the first postoperative radiograph, expressed in mm, was calculated. Categorical data are presented as absolute occurrence (percentage), while numerical data, which did not present normal distribution according to the Shapiro-Wilk test (alpha of 0.05), are presented as median (interquartile range [IQR]). The incidence of loss in radial height greater than 2 mm was calculated, and the effect of sex on this incidence was quantified by the odds ratio (OR), obtained in conventional logistic regression, and evaluated by the Wald test. The analyses and figures were developed using routines written in Python 3.10 (Python Software Foundation), with a significance level of 0.05.

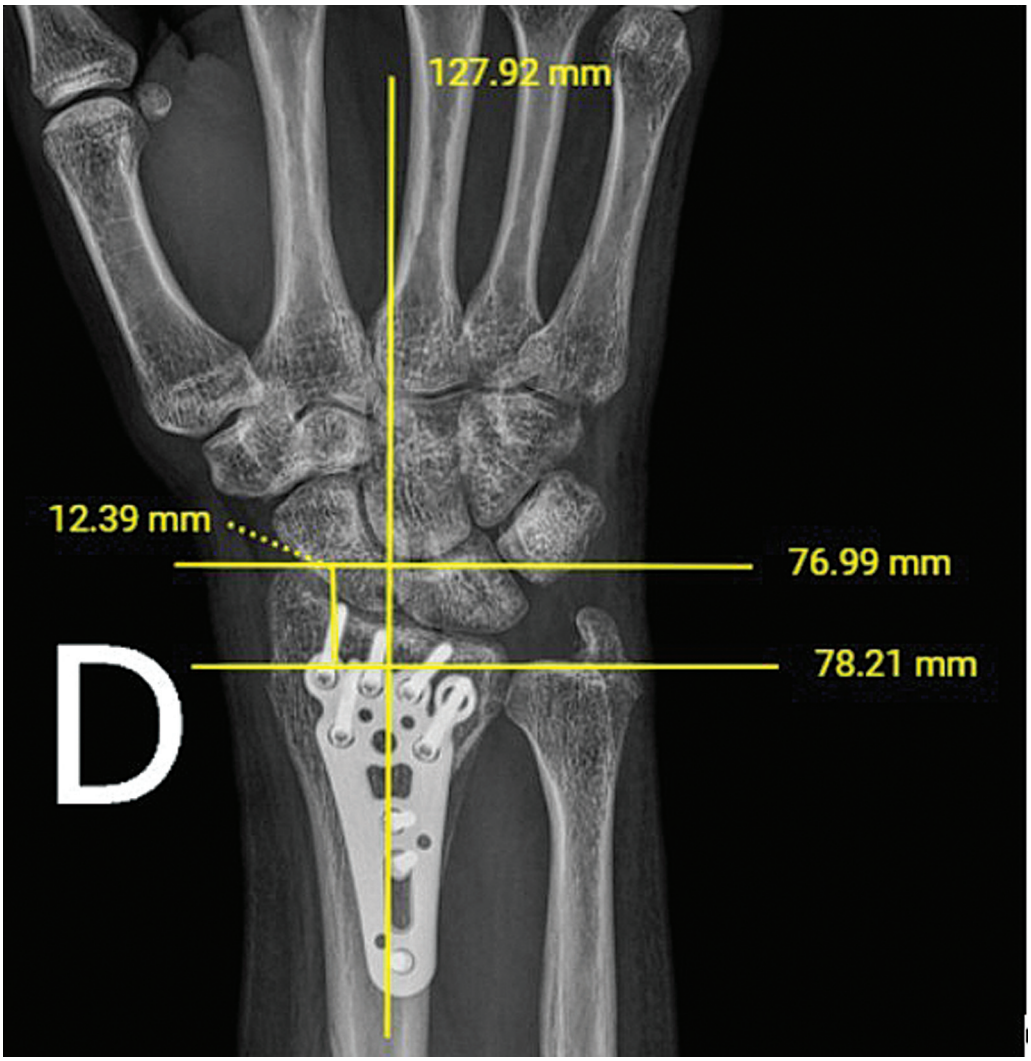


Fig. 2 Radial height in the immediate postoperative period.

Results

Data from 114 wrists were analyzed; 65 with a minimum follow-up of 3 months were included. Data were obtained from 62 patients, including 3 cases of bilateral fracture.

Among unilateral cases, the left side was affected in 41 cases and the right in 18. The median age was 54 years, with IQR of 46 to 61; 33 (53.2%) were women, and 29 (46.8%) were men. The median follow-up time was 6 months (IQR 4-10), ranging from 3 to 18 months (►**Fig. 4**).

Considering the last measurement obtained for each wrist, a height loss of 0.60 mm (0.14–1.43) was observed, with a maximum of 5.83 mm (►**Fig. 1**). No level of depression was detected in 7 (10.8%) wrists, while 49 (75.4%) presented detectable losses of up to 2 mm, and 9 (13.8%) presented greater losses during the period analyzed (►**Table 2**). Two cases of loss greater than 2 mm were observed among men and 7 among women, corresponding to 6.7% and 20.0%, respectively. No statistically significant effect of sex on this incidence was found using the Wald test (OR = 3.5; $p = 0.138$) (►**Fig. 5**).

Using the IDEAL classification system for patient evaluation and respecting our inclusion and exclusion criteria, only type-II patients were evaluated. This is because in type I, patients are treated conservatively, whereas in type III, patients require combined methods of osteosynthesis or bone grafting.[17]

Two cases of radial height increase were observed, and the parameter returned to the value visualized on the first radiograph in subsequent measurements. Another 2 cases were also observed with only 2 postoperative follow-up radiographs demonstrating an increase in radial height greater than 1 mm (these 4 cases are described with those who did not lose radial height). This phenomenon can be explained by variability in the radiographic technique and has also been observed by other authors in subsequent radiographic follow-ups.[18]

Discussion

Distal radius fractures are among the most common fractures in osteoporotic patients and the older population. With

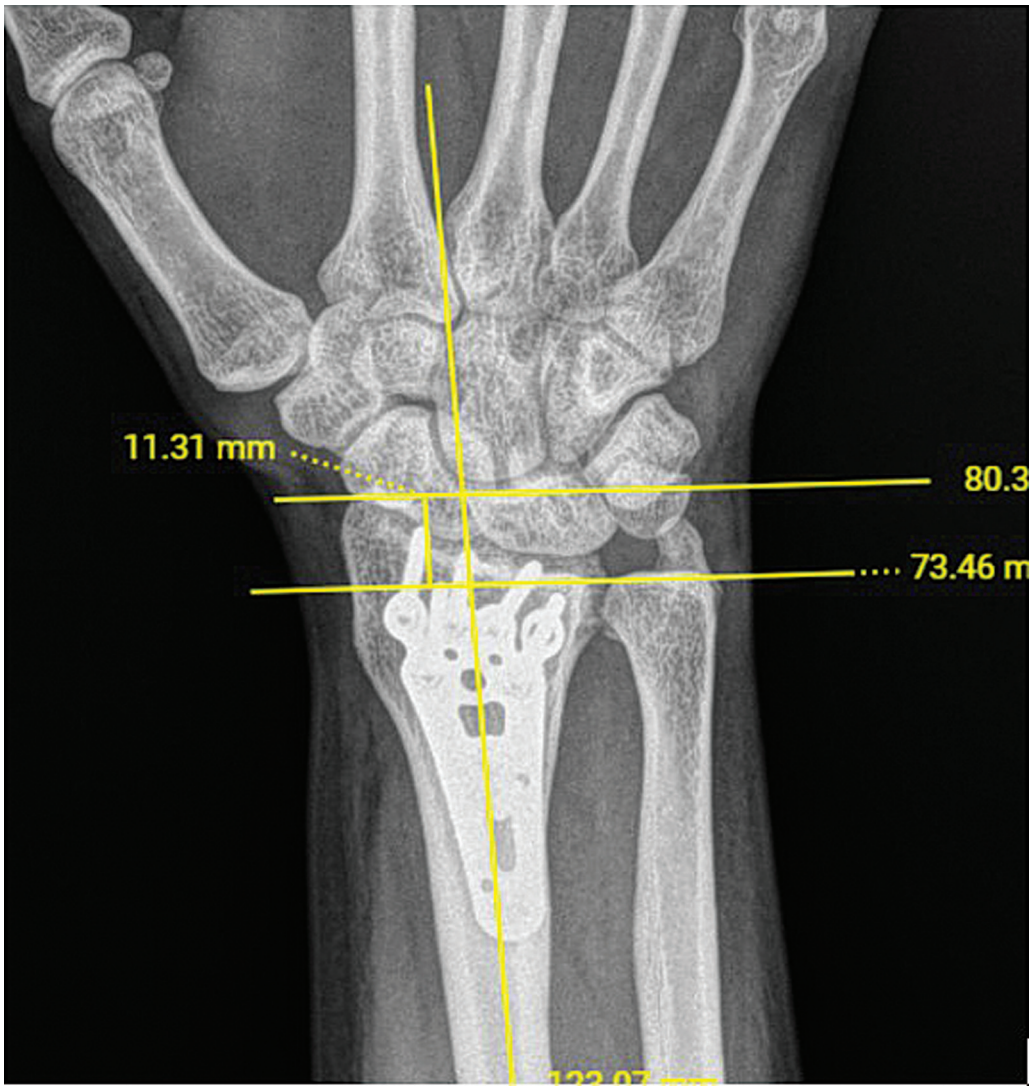


Fig. 3 Radial height change over a period of six months.

Table 1 IDEAL classification

	Characteristics	0 points	1 point
I	Age	< 60 years	> 60 years
D	Deviation	No	Deviation that needs reduction
E	Energy[1]	Low	High
A	Articular incongruity	No	Incongruity or gap > 2 mm
L	Associated injuries[2]	Absent	Present

Notes: 1. LOW: fall from own high/HIGH: others.
2. Open fractures/carpal bone fractures/carpal instability/distal ulna fracture.

Classification	Score	Description	Treatment	Prognosis
I	0–1 points	Stable	Conservative	Good
II	2–3 points	Potentially unstable	External fixation, percutaneous K-wire fixation, and plate fixation	Fair
III	4–5 points	Complex	Associated methods, bone grafting	Poor

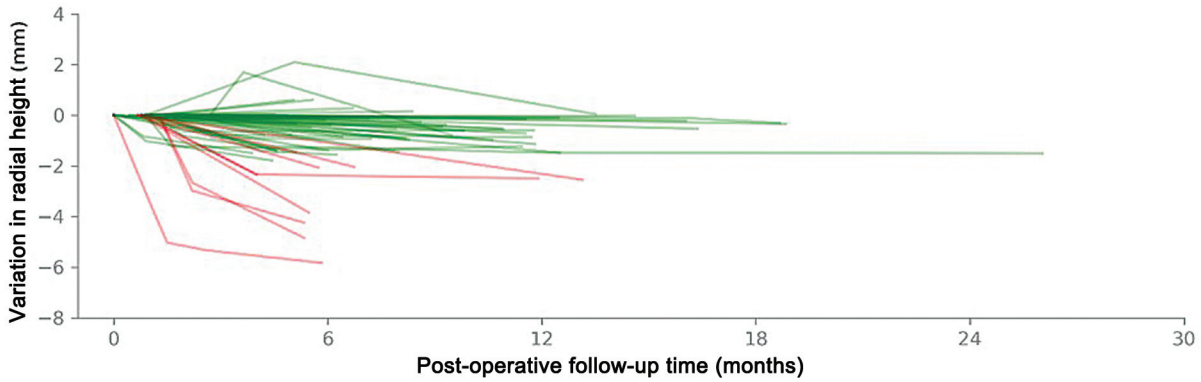


Fig. 4 Variation in radial height of the wrists followed-up. Each wrist is represented by an individual line, with those with height loss greater than 2 mm shown in red and the others in green.

Table 2 Sample demonstrative

	N	%
No loss of radial height	7	10.8%
Loss of radial height up to 2 mm	49	75.4%
Loss of radial height higher than 2 mm	9	13.8%
Total	65	100%

greater fragility, especially in the metaphyseal portion of the bone, fixing these fractures is a challenge. With the advent of anatomical locking plates for the distal radius, which promote angular stability with locking screws, surgeons expect maintenance of reduction and the possibility of early rehabilitation. However, studies[19] show that even with locking plates, there is a loss of postoperative reduction parameters.

Figl et al.[20] in 2009 evaluated 58 patients aged 75 years or older for 13 months, investigating secondary loss of reduction after osteosynthesis with the volar locking plates in patients with distal radius fracture, with no change in volar tilt. Cheng et al.[19] found a mean loss of 1.3 ± 0.9mm in radial height at 1-year follow-up. The present study indicates that 9% of patients had a mean loss in radial height of 1.3 mm, with no change in radial or volar tilt. These data are consistent with the literature on the subject.

Similarly, Cheng et al.[19] evaluated 87 patients with distal radius extra-articular fracture fixed with a locking volar plate, observing a mean radial height loss of 1.3 ± 0.9 mm. According to the author, advanced age, positive ulnar variance, changes in bone densitometry, and a shorter distance between the fracture focus and the radiocarpal joint were associated with loss of radial height. In this study, 89.2% of the patients evaluated had some degree of radial height decrease, with only 13.8% of patients with radial height loss greater than 2 mm.

Our sample had mean age of 54 years and considering that advanced age is a risk factor for the loss of radial height, we observed results consistent with those reported in the literature regarding the mean loss of radial height. One reason for this finding is the severity of the cases we operate on at our institution, as we are a quaternary care center within the health system. Thus, we observed other risk factors acting indirectly, such as bone densitometry, a shorter distance between the fracture focus and the radiocarpal joint, and the degree of fragmentation.[15,21]

An article by Thompson[22] described, in its systematic review, the presence of other possible complications, including carpal tunnel syndrome (2–3%), tendon rupture (1–2%), and the need for removal of synthetic material (6%). In addition, a study by Xavier et al.[23] pointed out that loss of radial height was associated with a grip strength deficit and loss of arc motion.

According to the IDEAL classification system, fractures classified as type II exhibit deviation and are considered potentially unstable. They have a high risk of loss of reduction and evolution to vicious consolidation, either due to low bone quality in older patients, high-energy trauma in young people, the presence of joint incongruence, or even associated injuries in any age group.[17] In this context, we can observe that in this group, the loss of radial height during postoperative follow-up had a mean of less than 2 mm.

Farhan et al.[24] demonstrated that, in patients with more complex cases treated with an association of osteosynthesis methods, the mean radial height was 8.5 mm. This represents a loss greater than 2 mm. Therefore, we conclude that in cases defined as type III as per the IDEAL classification, there is a greater chance of radial height.

The present study, having evaluated a good number of patients and used the same locking plate model, gives reliability to the results obtained. In line with the current literature on the subject, corroborating and encouraging the use of a locking plate for distal radius fractures to seek to restore and maintain the anatomical parameters of the region.

However, it is critical to shine a light on the negatives. The loss to follow-up of 42.9% of patients in the initial sample shows that this is difficulty in public services, in addition to the relevant number of patients who were operated on with a non-ideal fracture time (greater than 4 weeks) and were excluded from the sample. In addition, there is a possible selection bias in the profile of fractures and patients

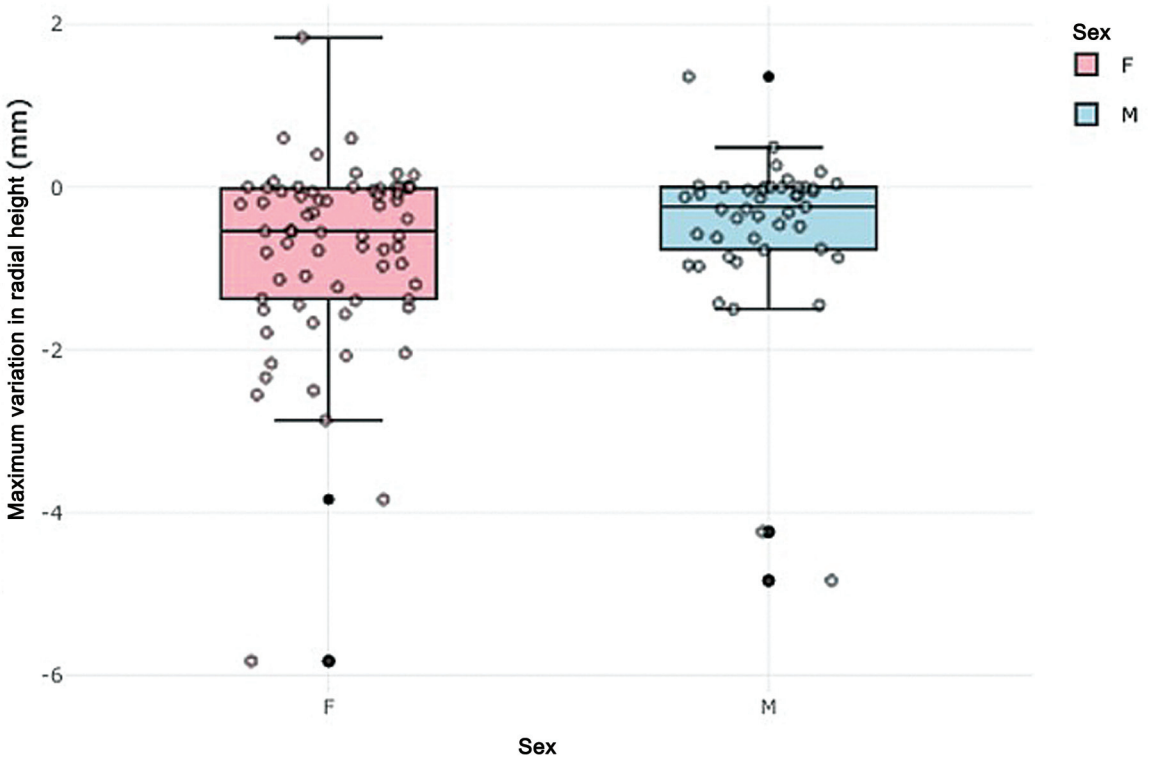


Fig. 5 Postoperative variation of radial height (in mm), by sex.

operated at this institution (a quaternary service), as well as in the evaluation/subdivision of cases based on their preoperative parameters, which may be analyzed in future articles.

Our article has some positive insights. The first is that a good number of patients were evaluated, which increases the reliability of the results. According to the same locking plate model, interfering as little as possible with the surgical technique and subsequent analysis. Finally, sample homogeneity, as seen in patients classified only as type II as per the IDEAL classification, reduces biases that could confuse the results. However, it is essential to highlight the limitations observed, such as the variation in fracture severity and the short follow-up time. In addition, there was no functional evaluation of the patients correlated with the radiographic parameters, as this was not the main objective of the study and was considered a possibility for a future study. Thus, it is essential to continue monitoring to consolidate results and inform future analyses.

Conclusion

Although anatomical locking plates of the distal radius offer angular stability to the locking screws, a loss of radial height is expected in the postoperative follow-up. However, in most patients, a loss of less than 2 mm is expected. The present study corroborates the use of this osteosynthesis technique, which is a fundamental tool in the approach of complex fractures of the distal third of the radius, to restore and maintain the anatomy of the region. Finally, more studies are essential for correlational assessment between functionality and radiographic parameters.

Data Availability

Data will be available upon request to the corresponding author.

Authors' Contributions

HTAC, YPDM, FPS, and EMH: data curation, research, methodology, writing – original draft, and writing – review & editing; and JCOSP and SFA: conceptualization, formal analysis, validation, supervision, and writing – critical review and final approval of the version to be published.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Use of Patch Augmentation in Rotator Cuff Repair: A Systematic Review Protocol

Uso de enxerto como reforço no reparo do manguito rotador: Um protocolo de revisão sistemática

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Abstract

Objective To evaluate the effectiveness of using a graft for reinforcement in rotator cuff repair compared to no use, as well as the effectiveness of different types of grafts, considering healing and shoulder function as primary outcomes, through a systematic review and meta-analysis of randomized controlled trials (RCTs).

Methods We will conduct a systematic review of RCTs following the guidelines of the *Cochrane Handbook for Systematic Reviews of Interventions* and of the Preferred Reporting Items for Systematic reviews and Meta-Analyses for Protocols (PRISMA-P) statement. Only RCTs with adult participants comparing repair with a reinforcing graft versus the standard repair, or comparing different types of grafts, will be included. An electronic search will be conducted in the MEDLINE (PubMed), Cochrane Central Register of Controlled Trials (CENTRAL), Embase, and SciELO databases, as well as gray literature. Data management and extraction will be performed using a standardized form that will assess the characteristics of the studies, participants, and intervention, as well as the outcomes and methodological domains. The primary outcomes will be healing and shoulder functional assessment, and the secondary outcomes, pain, range of motion, adverse events, complications, quality of life, and cost-effectiveness. Risk of bias will be assessed with the Risk of Bias, version 2.0 (RoB 2.0), and the certainty of evidence, through the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach. Descriptive, subgroup, and sensitivity analyses will be performed when applicable.

Conclusion The review is expected to consolidate evidence on the effectiveness of using a graft for reinforcement in rotator cuff repair. It has been registered in the International Prospective Register of Systematic Reviews (PROSPERO) under number 1106892.

Keywords

- allografts
- autografts
- heterografts
- rotator cuff
- rotator cuff injuries
- tissue scaffolds

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Resumo

Objetivo Avaliar a eficácia do uso de enxerto como reforço no reparo do manguito rotador comparado ao não uso, e a eficácia de diferentes tipos de enxerto, considerando a cicatrização e a função do ombro como desfechos primários, por meio de uma revisão sistemática e metanálise de ensaios clínicos randomizados (ECRs).

Métodos Realizaremos uma revisão sistemática de ECRs conforme as diretrizes do *Cochrane Handbook for Systematic Reviews of Interventions* e da declaração de Preferred Reporting Items for Systematic reviews and Meta-Analyses for Protocols (PRISMA-P). Serão incluídos apenas ECRs com participantes adultos que comparem o reparo com enxerto como reforço e o reparo-padrão, ou que comparem diferentes tipos de enxertos. Será realizada uma busca eletrônica nas bases MEDLINE (PubMed), Cochrane Central Register of Controlled Trials (CENTRAL), Embase e SciELO, além de literatura cinzenta. O gerenciamento e extração de dados serão conduzidos com formulário padronizado que avaliará as características do estudo, dos participantes e da intervenção, além dos resultados e dos domínios metodológicos. Os desfechos primários serão a cicatrização e a avaliação funcional do ombro, e os secundários, dor, amplitude de movimento, eventos adversos, complicações, qualidade de vida e a relação custo-eficácia. O risco de viés será avaliado por meio do Risk of Bias, versão 2.0 (RoB 2.0), e a certeza da evidência, por meio da abordagem Grading of Recommendations Assessment, Development, and Evaluation (GRADE). Quando aplicável, serão realizadas, análises descritivas, de subgrupos e de sensibilidade.

Conclusão Esta revisão espera consolidar evidências sobre a eficácia do uso de enxerto como reforço no reparo do manguito rotador. Este estudo foi inscrito no International Prospective Register of Systematic Reviews (PROSPERO) sob o número 1106892.

Palavras-chave

- alicerces teciduais
- aloenxerto
- autoenxertos
- lesões do manguito rotador
- manguito rotador
- xenoenxertos

Introduction

Rotator cuff injuries represent a growing challenge in shoulder surgery, as their prevalence increases with age.[1] Such injuries are the main shoulder pathology, and the surgeries to treat them are the most commonly performed in the epidemiological context of shoulder pathologies.[2] The repair failure rate, despite the constant technical advancement and scientific improvement, is significant, ranging from 30 to 40% in primary surgeries, with studies[3,4] showing predictive values of up to 80 to 90% of non-healing, depending on important factors such as healing, injury size, and the degree of atrophy of the rotator cuff muscles. This scenario directly affects patients' quality of life and the need for reinterventions, thereby increasing health costs. In the healthcare context of the United States,[5] the indirect costs of rotator cuff repair failure are estimated at hundreds of thousands of dollars.

Different strategies have been explored to minimize failures, including double-row repair, superior capsular reconstruction, and tendon transfers.[6,7] However, the placement of materials for reinforcement, called *grafts* or *patches*, has gained prominence. These materials can be biological (deriving from humans and animals) or synthetic, improving scar support and mechanical reinforcement and promoting better healing and repair resistance.[8]

Recent research[9,10] suggests a 30% reduction in rupture rates and improvements in functional scores with augmentation. A survey of surgeons in the United Kigdom[11] revealed that 70% of those using augmentation do so for large or extensive injuries, but there is still disagreement over the best type of patch and the optimal indication.

Despite evidence from various studies, there is a lack of recent systematic reviews based solely on randomized controlled trials (RCTs), which justifies conducting a systematic review with meta-analysis based exclusively on RCTs. Only 3 previous reviews were found in the literature, but all were published more than 5 years ago and evaluated trials with low levels of evidence, such as non-randomized studies, case series, and retrospective studies. The overall strategy will be developed around the key concepts of the Population, Intervention, Comparison, Outcome, Study Design (PICOS) strategy: population – patients with rotator cuff injuries; intervention – augmentation with patch; comparison – repair without augmentation (control) or with another type of augmentation with graft; outcome – tendon healing and functional outcomes; and study design – systematic review.

Therefore, the objective is to compare the effectiveness of graft use versus non-use for reinforcement, as well as the different types of grafts in rotator cuff repair, considering

shoulder healing and function, through a systematic review and meta-analysis of RCTs.

Study Type

The present study is a systematic review of RCTs evaluating the effectiveness of tendon healing and functional outcomes in adults with rotator cuff injuries undergoing repair with augmentation, using any type of patch (biological or synthetic). The study will follow the recommendations proposed by the *Cochrane Handbook for Systematic Reviews of Interventions* and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Protocols (PRISMA-P) (►**Annex 1**).[12,13]

Ethics and Records

The study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under number 1106892, with the title "Patch Augmentation in Rotator Cuff Repair: A Systematic Review and Meta-analysis of Randomized Controlled Trials."

Inclusion and Exclusion Criteria

Eligible articles are RCTs or quasi-randomized trials with adult participants (older than 18 years) who underwent total rotator cuff repair and compared the use of a graft as reinforcement with repair alone or with another graft.

The following exclusion criteria will be adopted: non-randomized, non-comparative, cadaveric, cohort, observational, case reports, case-control, and animal studies. Studies that include additional procedures without associated rotator cuff repair or the use of graft for another purpose (such as upper capsule reconstruction) will also be excluded.

Primary Outcomes

The primary outcomes will be rotator cuff healing and shoulder function.

Tendon healing will be assessed using imaging methods, such as magnetic resonance imaging (MRI) or ultrasound (US). The evaluation of structural integrity will be dichotomous (presence or absence of rerupture), and it will be based on classification criteria standardized and validated in the literature, such as those proposed by Sugaya et al.,[14] a classification widely used to describe postoperative structural integrity, as well as the evaluation of the absolute number of reruptures.

Shoulder function will be assessed from postoperative follow-up using validated scores such as the Constant-Murley Score (CMS),[15] the American Shoulder and Elbow Surgeons Society Standardized Shoulder Assessment Score (ASES),[16] the Penn Shoulder Score (PSS),[17] and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.[18] Should shoulder function be assessed using other validated scores, these will also be considered and, if applicable, their measurements will be converted to a common metric, as appropriate.

To evaluate the clinical implications of the outcomes, we will use the concept of clinically-important minimum difference (CIMD), a statistical model that defines the smallest

Annex 1 PRISMA-P 2015 checklist

Section/Topic	Item nr.	Checklist item	Page nr.
ADMINISTRATIVE INFORMATION			
Title			
Identification	1a	Identify the report as a protocol of a systematic review	1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	–
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	1
Authors			
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	Title page
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	Title page
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	–
Support			
Sources	5a	Indicate sources of financial or other support for the review	Title page
Sponsor	5b	Provide name for the review funder and/or sponsor	Title page
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	Title page

(*Continued*)

Annex 1 (*Continued*)

Section/Topic	Item nr.	Checklist item	Page nr.
INTRODUCTION			
Rationale	6	Describe the rationale for the review in the context of what is already known	4
Objectives	7	Provide an explicit statement of the question(s) the review will address regarding PICOS	4
MATERIALS AND METHODS			
Eligibility criteria	8	Specify the study characteristics (such as PICOS, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	5
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	7
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	7
Study records			
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	8
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	8
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	8
Data items	12	List and define all variables for which data will be sought (such as PICOS items, funding sources), any pre-planned data assumptions and simplifications	8,9
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	9
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	10
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised	12
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall's Tau)	9
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	11
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	10
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	10
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	11

Abbreviations: GRADE, Grading of Recommendations Assessment, Development, and Evaluation; PICOS, Population, Intervention, Comparison, Outcome, and Study Design; PRISMA-P, Preferred Reporting Items for Systematic reviews and Meta-Analyses for Protocols; PROSPERO, International Prospective Register of Systematic Reviews.

change in a score or scale that the patient considers significant for their health status.

Secondary Outcomes

As secondary outcomes, we will also evaluate pain (using validated scales), the range of motion, and related quality-of-life scores, such as the 36-Item Short Form Survey (SF-36). Additionally, the study will investigate and record adverse events, postoperative complications, and poor outcomes, including, but not limited to, infections, persistent stiffness, and the need for surgical reintervention.

All outcomes will be evaluated following the length of the period: short term (up to 6 months), medium term (6 months to 2 years), and long term (longer than 2 years)

Search Methods and Strategies

The electronic search will be performed on the MEDLINE (via PubMed), Cochrane Central Register of Controlled Trials (CENTRAL), Embase, and SciELO databases. In addition, the grey literature, such as Google Scholar, will be evaluated, as well as the reference lists of the included studies and the annals of the main congresses on the subject, to search for additional relevant studies not captured in the primary electronic search. No language or publication date restrictions will be imposed.

Search strategies will be developed to maximize sensitivity and specificity. For each database, a search will be developed that combines controlled terms (when applicable, such as medical subject headings [MeSH] in PubMed/MEDLINE and Emtree in Embase) and free-text terms (keywords and synonyms), using Boolean operators (AND, OR). The overall strategy will be developed around the key concepts of the PICOS strategy (►**Annex 2**).

Data Collection, Extraction, and Analysis

Two authors will independently select the studies eligible for this systematic review through the title and abstract using the following criteria: 1) RCTs; 2) presence of total rotator cuff injury; 3) surgical repair using graft reinforcement (biological, animal or human, and synthetic); and 4) comparative control group, either without augmentation or with the use of different patches. The review will be performed in two stages: primary analysis of the title and abstract, and, from the included studies, the reading of the full text. The selected studies will be reviewed in full to determine their eligibility, and any disagreement will be resolved through discussion and, when necessary, will be judged by a third party in an attempt to resolve a possible conflict. Two reviewers will perform the extraction of the data, which

Annex 2 Search strategy

Database	Search terms	Recommended filters
MEDLINE (via PubMed)	(*Rotator Cuff*[Mesh] OR *Rotator Cuff Injuries*[Mesh] OR *rotator cuff tear** OR *rotator cuff injur** OR *massive rotator cuff tear** OR *large rotator cuff tear**) AND ("Surgical Procedures, Operative"[Mesh] OR "rotator cuff repair" OR "arthroscopic repair") AND ("Biocompatible Materials"[Mesh] OR "Tissue Scaffolds"[Mesh] OR patch OR graft OR augmentation OR scaffold OR "biologic augmentation" OR "synthetic patch" OR "acellular dermal matrix") AND ("Randomized Controlled Trial"[Publication Type] OR "randomized controlled trial" OR "RCT")	Humans; Adults; Randomized clinical trials
Cochrane Central Register of Controlled Trials (CENTRAL)	(rotator cuff OR "rotator cuff tear" OR "rotator cuff injuries") AND (augmentation OR patch OR graft OR scaffold OR "acellular dermal matrix" OR "biologic augmentation" OR "synthetic patch") AND ("rotator cuff repair" OR surgery OR "arthroscopic repair")	*Trials > randomized*
EMBASE	('rotator cuff injury'/exp OR 'rotator cuff tear' OR 'rotator cuff repair' OR 'massive rotator cuff tear') AND ('augmentation'/exp OR 'tissue scaffold'/exp OR patch OR graft OR 'acellular dermal matrix' OR 'synthetic patch' OR 'biologic augmentation') AND ('randomized controlled trial'/exp OR 'randomized controlled trial')	Type of study: Randomized clinical trials; only humans; Age: Adult
SciELO	("manguito rotador" OR "lesão do manguito rotador" OR "rotator cuff") AND ("enxerto" OR "patch" OR "aumento" OR "augmentação" OR "scaffold" OR "matriz dérmica acelular") AND ("ensaio clínico randomizado" OR "estudo clínico randomizado" OR "randomized controlled trial")	Type of article: clinical trial

will be arranged in an appropriate custom form in the Excel (Microsoft Corp.) software, version 16.34, based on: 1) the characteristics of the studies, including authors, year of publication, sample size (total and per group), loss to follow-up, sociodemographic characteristics of the participants (mean age, sex, comorbidities, others), number of patients, inclusion and exclusion criteria, and follow-up time; 2) the characteristics of the intervention, such as type of surgery, use of which patch for augmentation; 3) the outcomes during the postoperative follow-up, for function (functional scores) as well as pain, range of motion, tendon healing, and complications; and 4) the methodological domains and biases.

Data Treatment

The resulting dichotomous data will be analyzed using odds ratios (ORs) and 95%CIs. Continuous data will be expressed as mean differences (MDs) or standardized mean differences (SMDs) with 95%CIs. The outcomes will be grouped with the MD if two or more trials reveal outcomes from the same validated assessment instrument (with the same units of measurement). If the primary studies measure the same outcomes, such as shoulder function through different instruments (as well as different units of measurement), the MD will be transformed into the SMD, enabling the evaluation of the outcomes, regardless of the original units of measurement.

Statistical heterogeneity will be assessed using the Cochran's Q-test and the I^2 index. The Cochran's Q-test will be used to verify the statistical significance of the heterogeneity, with values of $p < 0.10$ considered indicative of significant heterogeneity, given their low power in meta-analyses with few studies. The I^2 index will be used to quantify the heterogeneity across studies, expressing the percentage of the total effect variation observed that is due to true heterogeneity rather than chance. The interpretation of I^2 will be according to the following guidelines: 0 to 40% (may not be important); 30 to 60% (moderate heterogeneity); 50 to 90% (substantial heterogeneity); and 75 to 100% (considerable heterogeneity). A random-effects model will be used to group the outcomes, given the likely clinical and methodological heterogeneity across the included studies, even when the heterogeneity test is not statistically significant. The Review Manager (RevMan, The Cochrane Collaboration) software, version 5.3, (will be used for the statistical analyses.

When quantitative data are available for outcomes of interest, with standardizable metrics, and the heterogeneity among studies is considered acceptable, a meta-analysis will be performed. In case of significant heterogeneity, subgroup analyses and/or meta-regression will be explored, if the number of studies enables them. When applicable and with a sufficient number of studies, paired and networked meta-analyses will be considered for each outcome.

Risk of Bias Assessment

Two authors will independently evaluate aspects of the methodological reliability of the studies using the Risk of Bias 2.0 (RoB 2, The Cochrane Collaboration) tool,[19] which is specific for RCTs, considering the four main domains addressed (bias due to deviations from the planned intervention, bias due to missing outcome data, bias in the measurement of outcomes, and bias in the selection of reported results). Disagreements between reviewers will be resolved by consensus or by a third reviewer.

Sensitivity Analysis

The sensitivity analysis will involve the progressive exclusion of studies with heterogeneous methodological characteristics or confounding factors that may compromise the validity of the results. Studies excluded in the sensitivity analysis will not be removed from the main analysis, but will be used to assess the potential impact on the overall effect estimate. In quantitative analyses with a sufficient number of studies, a funnel graph may be used, along with Egger or Begg tests, to investigate publication bias, and the symmetry of the distribution of effects may be assessed.

Quality of Evidence

Additionally, the quality of evidence for each critical outcome will be assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.[20]

The following criteria will be considered for the grading of evidence in the quality aspect: 1) bias due to deviations from the planned interventions; 2) bias due to missing outcome data; 3) bias in the measurement of outcomes; 4) bias in the selection of reported outcomes; 5) bias due to the randomization process; and 6) bias due to allocation concealment and blinding.

Evidence will be classified as high, moderate, low, or very low quality. Additionally, the quality of the evidence may be increased based on three factors: high magnitude of the effect, dose-response relationship, and absence of biases that explain the observed effect.

Missing Data

An intent-to-treat analysis will be performed, including all randomized participants in each intervention. The authors of the selected trials will be contacted if insufficient information is available. An analysis will be performed regardless of data loss, according to the worst- and best-case scenarios.

Subgroup Analysis

The subgroups will be analyzed to explore the difference in the outcomes of each graft: comparison of the use and nonuse of graft in association with rotator cuff repair; comparison between the use of biological and synthetic grafts, as well as other relevant comparisons to understand the outcomes among the available techniques. In addition, the result for the subgroups will be evaluated according to the size of the injury and the number of tendons affected, if possible.

Data Synthesis

The data synthesis will include a description of the characteristics of the included studies (e.g., population,

intervention, comparison, outcomes, and risk of bias), facilitating the identification of studies eligible for meta-analysis. For the structured effects report, a random effect model and a 95% CI will be used. Consideration of the direction and magnitude of the effect, the certainty of the evidence, the interventions tested, and the populations in which they were tested will be included. The variable model will be used when there is diversity in clinical or methodological characteristics.

Discussion

Rotator cuff injuries are one of the main shoulder pathologies. In this context, rotator cuff repair is one of the most frequently performed surgeries. One challenge that persists is the high rate of repair failure, whether due to re-healing or non-healing of the tendon. This has important implications for the patient's quality of life and the need for reinterventions, and it is essential to evaluate the effectiveness of different treatment strategies. The use of graft reinforcement is an explored technique that acts as mechanical and biological reinforcement for repair.

A systematic review and meta-analysis of RCTs constitutes high-level scientific evidence for assessing the effectiveness of treatments. As primary outcomes, we will use objective measures of tendon healing via MRI or US and functional improvement, as assessed with validated scores. This combination provides an overview of the clinical and structural success of the procedure. The evaluation across short-, medium-, and long-term periods provides evidence on the longevity of the results. Additionally, we will investigate secondary outcomes, including pain, range of motion, complications, and adverse events. The use of subgroup analyses and the evaluation of heterogeneity allow us to observe differences in outcomes across different graft types and injury sizes, as the magnitude of the benefit can be influenced by graft material, the technique employed, and patient characteristics, reinforcing the need for recommendations.

Considering that the current literature addresses several treatment options for rotator cuff injuries, there is still a lack of high-level scientific evidence to support clinical practice. Therefore, this systematic review will consolidate existing evidence and clarify the role of this technique in rotator cuff repair.

Data Availability

Data will be available upon request to the corresponding author.

Authors' Contributions

The authors declare their individual and significant contributions to the development of the present article. VPP, BCBS, and NA: writing – original draft; FTM: writing – original draft and writing – review & editing; JCB: writing – review & editing; and MJST: conceptualization and writing – review & editing.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Reply to the Letter to the Editor Regarding "Description of Hip Deformities in 5-Year-Old Patients with Congenital Zika Virus Syndrome: A Cross-Sectional Study"

Resposta à carta ao editor sobre "Descrição das deformidades do quadril em pacientes com síndrome congênita do Zika vírus aos 5 anos de idade: Um estudo transversal"

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We appreciate the pertinent observation regarding the risk of selection bias. We recognize that, as this is a retrospective cross-sectional study, this methodological limitation cannot be eliminated. However, we sought to reduce this bias as much as possible by including all children with congenital Zika virus syndrome who attended the outpatient clinic consecutively during the analyzed period, provided that they met the previously defined inclusion criteria. Thus, there was no arbitrary choice of cases, but rather the use of a representative sample of the population assisted in a reference center. We believe this strategy significantly reduced the risk of distortion in the results, even if it does not eliminate the limitations inherent in the retrospective design.

We agree with the observation that the sample size (62 patients) may limit more complex statistical analyses, especially when the data are stratified by gross motor function classification system (GMFCS) levels, which naturally reduces the number of individuals in each subgroup and, consequently, the accuracy and statistical power. We also recognize that the absence of confidence and control intervals for confounding variables, such as comorbidities or nutritional factors, is a limitation of the present study. However, we emphasize that its aim was to provide an initial description of hip structural changes in a specific population of children with congenital Zika virus syndrome, a topic still little explored in the literature. We emphasize that overcoming these limitations requires multicenter studies with larger numbers of participants and a prospective design, which will yield more robust analyses and better control of confounding variables.

We understand that the lack of methodological detail regarding covariate control may, in fact, have limited the interpretation of the results. However, we emphasize that, in our analysis, the variables Reimers index (RI), acetabular index (AI), and femoral neck-shaft angle (FNSA) were paired between patients who underwent tenotomy and those who did not, to detect statistical differences.[1] We recognize that this is a relevant point to improve in future versions and in subsequent studies with a larger number of cases.

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We appreciate the considerations presented, especially regarding the issues raised to foster academic discussion. We recognize that such questions are extremely pertinent and enrich the reflection on the findings of our study. Although not directly explored in this analysis, we consider that these points represent relevant paths for future investigations and may support the development of new studies with more specific designs.

Suggestions regarding possible directions for future studies are valuable. We consider proposals for longitudinal designs to be extremely relevant, along with expanded and multicenter samples, and the incorporation of new technologies, such as three-dimensional (3D) modeling and artificial intelligence, to deepen understanding of the structural and functional changes of the hip in children with congenital Zika virus syndrome. Certainly, such approaches represent promising paths to generate more robust evidence and support individualized care strategies for this population.

Data Availability

Data will be available upon request to the corresponding author.

Conflict of Interests

The authors have no conflict of interests to declare.

Reference

1 Oliveira HFV, Rego FRQ, Cavalcanti BdS, Bacellar IR, Barbosa TA, Rolim Filho EL. Description of Hip Deformities in 5-Year-Old Patients with Congenital Zika Virus Syndrome: A Cross-Sectional Study. Rev Bras Ortop 2025;60(01):s00441800922. Doi: 10.1055/s-0044-1800922

Description of Hip Deformities in 5-Year-Old Patients with Congenital Zika Virus Syndrome

Descrição das deformidades do quadril em pacientes de 5 anos de idade com síndrome congênita do vírus Zika

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Rev Bras Ortop 2025;60(6):s00451814120.

Dear Editor,

The purpose of the study "Description of Hip Deformities in 5-Year-Old Patients with Congenital Zika Virus Syndrome: A Cross-Sectional Study"[1] was to look at common hip anomalies in children over the age of five with congenital Zika virus syndrome (CZS) using clinical and radiographic examinations. Although the study provides helpful information for a specific patient population, it has methodological and statistical limitations that must be carefully evaluated. One example is the study's cross-sectional and retrospective design, which may add selection bias and limit the capacity to accurately discern cause and effect between variables.

The sample size of only 62 patients may be insufficient for complicated statistical analyses, particularly when stratified by GMFCS level, resulting in fewer individuals per group and lower precision and statistical power. Furthermore, no confidence intervals or controls for confounding variables, such as other medical histories or nutritional factors, that could influence hip structural development were given. Although comparison data were available, the relationships between variables such as Reimers Index (RI), acetabular index (AI), femoral neck-shaft angle (FNSA), and tenotomy did not clarify how the covariates were controlled or matched, which limited the results' interpretation.

Questions to inspire academic discussion include: Does the association between GMFCS and radiographic changes reflect genuine illness development, or is it merely the product of differences in movement habits between groups? Is the lack of a difference in FNSA across groups clinically significant? Is it related to sample size limitations? Another intriguing finding is that, while tenotomy increases leg extension, it has no effect on radiographic values, implying that surgical therapies should be evaluated for more than simply short-term clinical results.

Future studies should include cohort studies to evaluate long-term radiographic changes and mobility. Furthermore, sample sizes should be larger, and data from various locations should be incorporated to improve the generalizability of the findings. New technologies, such as 3D modeling of radiographic images or artificial intelligence for image analysis, should be employed to determine the intricate links between anatomical features and clinical outcomes, allowing for more effective individualized care in CZS patients.

Data Availability

Data will be available upon request to the corresponding author.

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AI Declaration

The authors used computation tool for language checking and editing.

Conflict of Interests

The authors have no conflict of interests to declare.

Reference

1 Oliveira HFVd, Rego FRQ, Cavalcanti BdS, Bacellar IR, Barbosa TA, Rolim Filho EL. Description of Hip Deformities in 5-Year-Old Patients with Congenital Zika Virus Syndrome: A Cross-Sectional Study. Rev Bras Ortop (Sao Paulo) 2025;60(01):s00441800922. Doi: 10.1055/s-0044-1800922

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EDITORIAL CONTACTS **9**

The Revista Brasileira de Ortopedia (RBO) is the official publication of the Brazilian Society of Orthopedics and Traumatology (Sociedade Brasileira de Ortopedia e Traumatologia, SBOT) dedicated to the publication of scientific articles that contribute to the dissemination of scientific knowledge and advances that contribute positively to the practice, research, teaching, and updating of orthopedics and traumatology and related areas. The RBO aims to provide an opportunity for the exchange of information between healthcare professionals, researchers, and educators, promoting the advancement of orthopedic science and improved patient care. It is published bimonthly in February, April, June, August, October and December, and has been published regularly since its first edition in 1965. The journal is dedicated to orthopedists who are linked to the SBOT, healthcare professionals who are dedicated to similar activities and orthopedists in other countries.

Peer Reviewing Process

The journal follows a double-blind peer-review process where neither author and reviewer does not get to know the identity of each other.

At least two reviewers are randomly appointed from their area of expertise, under the coordination of the Editor-in-Chief. The decision is taken based on the comparative reviews that the manuscript receives during the review process.

MANUSCRIPT FORMAT

Article Types

The following graph shows what types of articles are accepted for publication, and what requirement they may have.

Article Type	Abstract Limit	Keywords Limit	Title Limit	Illustrations	Reference
Original Article (up to 2,500 words)	Up to 250 words	Up to 6	N/A	16 (between figures, tables and graphs)	Up to 30 References
Update Articles (up to 4,000 words)	Up to 250 words	Up to 3	N/A	10 (between tabels and figures)	Up to 40 References
Review Articles (up to 4,000 words)	Up to 250 words	Up to 6	N/A	5 (between figures, tables and graphs)	Up to 40 References
Systematic Review and Meta-analysis Protocol (up to 2,500 words)	Up to 250 words	Up to 6	N/A	N/A	Up to 20 References
Randomized Controlled Trials Protocol (up to 2,500 words)	Up to 250 words	Up to 6 authors	N/A	N/A	Up to 20 References
Technical Notes (up to 1,500 words)	Up to 250 words	Up to 4	N/A	7 (between figures and tables)	Up to 10 References
Letters to the Editor (up to 500 words	N/A	N/A	N/A	2 Figures	Up to 4 References
Editorial (up to 500 words)	N/A	N/A	N/A	N/A	N/A

- **Original Article**: It describes prospective or retrospective experimental research or clinical investigations, which may be randomized or double blind. It should have a Title, Structured Abstract (Objective, Methods, Results, and Conclusion), keywords, introduction, materials and methods, results, discussion, conclusions and references. Can have maximum of 6 authors. Maximum of 2,500 words, 30 references, 16 illustrations (between figures, tables and graphs).
- **Update Articles**: Written by an expert at the invitation of the Commission for Continuing Education (CEC-SBOT) and the Editor-in-Chief, the article should present a review on a relevant and current topic, which may include diseases, technological advances, diagnostics, innovative surgical techniques and new therapeutic approaches, ensuring that practices are based on the best available evidence. It should be structured with: title (clear, objective and that reflects the topic addressed), abstract (unstructured) and keywords (up to six). The body of the article should provide a comprehensive and objective view, based predominantly on information published in the literature. Use subheadings to address the main aspects of the topic. Authors are expected to present all perspectives on controversial issues in a balanced way, highlighting innovations, discoveries, and new approaches in the specialty. At the end, summarize the main points discussed and the relevance of the advances for clinical practice. Maximum of 4,000 words, 60 references, 10 illustrations (including tables and figures).
- **Review Articles**: A systematic review with meta-analysis should address a clearly formulated clinical question and use reproducible systematic methods with the following distinct steps: elaboration of specific search strategies for each database to be explored; selection of studies, by at least two authors, according to previously clearly established inclusion and exclusion criteria; data extraction, considering all the outcomes measured and the follow-up time of the patients; evaluation of the methodological quality and analysis of potential biases of each included study; statistical analysis and synthesis of results; analysis of heterogeneity and publication bias; evaluation of the quality of the evidence generated by the study, ending with the appropriate writing following the minimum criteria of the guidelines already established in the literature, denoting that these are studies that require a long time to be carried out with a systematized and reproducible methodology. The results of

the systematic review (meta-analysis) can be synthesized using statistical methods, summarizing the results of the included studies Maximum of 4,000 words, 40 references, 5 illustrations (between figures, tables and graphs).

- The RBO establishes the following criteria to consider the publication of this type of study:
- Other types of review, such as: narrative, integrative, rapid review, mapping or scoping reviews, will not be considered for publication, except for those considered relevant by the editor-in-chief of the RBO.
- In the submission, authors must describe the relevance of the study and list the systematic reviews and meta-analyses published in the last five years on the topic. Submitted reviews that have similar studies on the same topic published in the last five years will not be accepted for publication (redundant studies), unless there is a substantial change in the results, justified by the authors.
- Only systematic reviews and meta-analyses on treatment that have included high-quality studies – randomized controlled trials – will be considered for publication.
- We recommend and encourage authors to submit systematic review protocols, observing the guidelines recommended by the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) and the Cochrane handbook for systematic reviews. The RBO establishes the following criteria to consider the publication of this type of study:
- Other types of review, such as: narrative, integrative, rapid review, mapping or scoping reviews, will not be considered for publication, except for those considered relevant by the editor-in-chief of the RBO.
- In the submission, authors must describe the relevance of the study and list the systematic reviews and meta-analyses published in the last five years on the topic. Submitted reviews that have similar studies on the same topic published in the last five years will not be accepted for publication (redundant studies), unless there is a substantial change in the results, justified by the authors.
- Only systematic reviews and meta-analyses on treatment that have included high-quality studies – randomized controlled trials – will be considered for publication.
- We recommend and encourage authors to submit systematic review protocols, observing the guidelines recommended by the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) and the Cochrane handbook for systematic reviews.

- **Systematic Review and Meta-analysis Protocol:** The protocol can be published in article format. Must contain the strategies methodologies for carrying out the systematic review and must contain at least the following information: a search strategy to identify articles of interest, eligibility criteria, data extracted, the variables of interest, data analysis, and forms to explore heterogeneities. The essential items inherent in performing a systematic review may be seen at the link: https://tinyurl.com/systematicr. RBO suggests that all researchers register the protocol of their systematic reviews in Prospero (https://www.crd.york.ac.uk/prospero/) or PRISMA (http://www.prismastatement.org/). The protocol will be evaluated by the journal's editorial board and submitted to the peer-review process.
- **Randomized Clinical Trial Protocols:** For submissions of randomized clinical trial protocols, it is mandatory to present the clinical trial registration number on the cover page at the time of submission. Revista Brasileira de Ortopedia accepts registrations made on any platform that meets the criteria of the International Committee of Medical Journal Editors (e.g., http://clinicaltrials.gov or ReBEC).
- **Technical Note:** The purpose of a surgical technique article is for a surgeon who reads and/or watches it (preferably accompanied by a video) to understand the indications, contraindications, the technique itself, postoperative care, and the results of a procedure. It is intended for the dissemination of diagnostic methods or surgical techniques. The technique presented must be well tested (with adequate follow-up time) or offer a solution to a problem that does not yet have well-established techniques in the medical literature. The article must contain: Title (clear, objective and that reflects the theme addressed), Abstract (unstructured), Keywords (up to six), Explanatory introduction, Selection of patients, Description of the method, Material or Technique, Final comments, References. Maximum of 1,500 words, 10 references, 7 illustrations (between figures and tables).
- **Letters to the Editor:** These have the aim to comment on or discuss works published in the journal or to report original research in progress. Publication is made at the discretion of the Editors, including the reply when relevant. Maximum of 500 words, 4 references, 2 figures.
- **Editorial**: These are written on invitation from the Editor-in-Chief, presenting comments on important studies in this journal, describing important published research or presenting communications from the editors that are of interest to the specialty.

General Guidelines

- You must submit a digital copy of your manuscript. Hard copy submissions are not accepted.
- Keep the format of your manuscript simple and clear. We will set your manuscript according to our style—do not try to "design" the document.
- The manuscript, including the title page, abstract and keywords, text, references, figure captions, and tables should be typewritten, double-spaced in 12-point font with 1-inch margins all around and saved as one file.
- Each figure should be saved as its own separate file. Do not insert figures within the manuscript file. This requires special handling by Thieme's Production Department.
- Keep abbreviations to a minimum and be sure to explain all of them the first time they are used in the text.
- The manuscripts should be written in consistent British or American English.
- The authors should use Système International (SI) measurements. For clarity, nonmetric equivalents may be included in parentheses following the SI measurements.
- Use generic names for drugs. You may cite proprietary names in parentheses along with the name and location of the manufacturer.
- Credit suppliers and manufacturers of equipment, drugs, and other brand-name material mentioned in the manuscript

within parentheses, giving the company name and primary location.

Files/Information Checklist:

- One of the authors can be designated as the corresponding author. The e-mail address and full postal address should be included in the title page. For more details, please see below the section of Title Page.
- Manuscript:
  - Include Keywords
  - All relevant Figures and their Figure captions/legends
  - All Tables (including titles, description, footnotes)
  - Ensure all figure and table citations in the text match the files provided
  - Indicate clearly if color should be used for any figures in print Graphical Abstracts / Highlights files (wherever applicable)
  - Supplemental files (wherever applicable)
- Further considerations
  - Manuscript has been 'spell checked' and 'grammar checked'
  - All references mentioned in the Reference List are cited in the text, and vice versa
  - Permission has been obtained for use of copyrighted material from other sources (including the Internet)
  - A competing interests statement is provided, even if the authors have no competing interests to declare
  - Journal policies detailed in this guide have been reviewed
  - Referee suggestions and contact details provided, based on journal requirements

Language

Articles can be written in Portuguese or English.

Title Page

- This journal adheres to a double-blinded peer-review policy. The title page should **not** be included in the main document and should be provided as a separate document.
- Article Title: Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
- Authorship: A maximum of 6 authors, except to the multicenter studies where the number of authors may be greater, as follows:

- Two or three institutions, a maximum of 4 authors per institution;
- More than four institutions, a maximum of 3 authors per institution.
- Under no circumstances, the number of authors can be greater than 20.

- Indicate each author's affiliation separately. If there is more than one institutional affiliation, only indicate the most relevant. Please clearly indicate the first and last name of each author with the correct spelling. List all affiliations to the respective authors, including city and country. Provide the ORCID (https://orcid.org/) email for each author. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the city, state and country name and, if available, the e-mail address of each author. Author affiliations should be presented in increasing hierarchical order (e.g. Harvard University, Harvard Business School, Boston, USA) and should be written as established in its own language (e.g. Universit Paris-Sorbonne; Harvard University, Universidade de So Paulo).
- Corresponding Author: Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.

Abstract and Keywords

See the section Article Types for word limits.

The abstract should briefly outline the content of the article and any conclusions it may reach. The keywords should be words a reader would be likely to use in searching for the content of the article.

A structured abstract, by means of appropriate headings, should provide the context or background for the research and should state its purpose, basic procedures (selection of study subjects or laboratory animals, observational and analytical methods), main findings (giving specific effect sizes and their statistical significance, if possible), and principal conclusions. It should emphasize new and important aspects of the study or observations.

The abstracts should be a maximum of 250 words and structured in the following format: Purpose: One or two sentences that simply state purpose with no background information. Methods: Provide details about the methods of the study, including data analysis. Results: Present most important findings of the study. Please provide numbers (means with standard deviations or medians with ranges) to support your findings, and results of significance tests, e.g. p-values. Conclusions: One or two sentences that state only what your study identified and actually demonstrated. Please do not include comments or information not supported by the data of your study. Level of Evidence (for human studies) or Clinical relevance (basic science in-vitro or in-vivo study: why is this study important from a clinical standpoint?).

Immediately after the abstract, provide a maximum of 6 keywords in alphabetical order and separated by semicolon, to represent the content of the article. The descriptors or keywords should be based on the Health Science Descriptors (Descritores em Cincias da Sade, DECS), which are available at the electronic address http://www.decs.bvs.br; or on the Medical Subject Headings (MeSH), from www.nlm.nih.gov/mesh/ MBrowser.html.

Main Document

- This journal uses **double-blind peer-review**, which means the identities of the authors are concealed from the reviewers, and vice versa. To facilitate this, please include the following separately:
  - Title page (with author details): This should include the title, professional qualification, academic title and affiliation of each author, acknowledgements and any Declaration of Interest statement, and a complete address for the corresponding author including an e-mail address.
  - Blinded manuscript (no author details): The main body of the paper (including the references, figures, tables and any acknowledgements) should not include any identifying information, such as the authors' names or affiliations.
- Articles including humans or animals must present the opinion with the approval provided by the specific committee in the submission and cited in the text.
- Use generic names of drugs or devices. If a particular brand was used in a study, insert the brand name along with the name and location of the manufacturer in parentheses after the generic name when the drug or device is first mentioned in the text.
- Quantities and units should be expressed in accordance with the recommendations of the International System of Units (SI), 8th edition 2006 (www.bipm.orgutilscommonpdfsi_brochure_8_en.pdf).
- When abbreviations are used, give the full term followed by the abbreviation in parentheses the first time it is mentioned in the text, such as inferior gleno-humeral ligament (IGHL).
- Please clearly distinguish the hierarchy of headings within the manuscript by using capital letters, underline, italic, and bold styles as necessary.
- As needed, use italic, superscripts, subscripts, and boldface, but otherwise do not use multiple fonts and font sizes.
- Do not insert page or section breaks except where noted in the Author Instructions.
- Use hard returns (the Enter key) only at the end of a paragraph, not at the end of a line. Allow lines of text to break automatically in your word-processing software. Do not justify your text.
- Use only one space, not two, after periods.
- Create tables using the Table function in Microsoft Word.

Acknowledgments

Present acknowledgments at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Formatting of Funding Sources

List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, please include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest Statement

All authors (including corresponding and co-authors associated with the manuscript) must make a formal statement at the time of submission indicating any potential conflict of interest that might constitute an embarrassment to any of the authors if it were not to be declared and were to emerge after publication. Such conflicts might include, but are not limited to, shareholding in or receipt of a grant or consultancy fee from a company whose product features in the submitted manuscript or which manufactures a competing product. Should the article be accepted for publication, this information will be published with the paper.

Please click http://www.icmje.org/conflicts-of-interest to download a Conflict of Interest form. The disclosure information is important in article processing. If the provided forms are incomplete or missing, it can cause delays in publishing of article.

Informed Consent

The journal adheres to the principles set forth in the "http://www.wma.net/en/30publications/10policies/b3/"Helsinki Declaration and holds that all reported research conducted with human participants should be conducted in accordance with such principles. Reports describing data obtained from research conducted in human participants must contain a statement in the Methods section indicating approval by the Institutional Review Board (IRB). The authors should also indicate whether or not individual consent for the study was obtained, or whether it was waived.

Conflicts arising from papers authored by Editorial Board Members

The journal evaluates any submissions from the members of the editorial board purely on merit of the clinical content presented as it does for any other article coming from authors globally. All the articles including articles from Editorial Board members are evaluated via double-blind peer review process, which will ensure that the information of author(s) is not revealed to the reviewers. In doing so, the journal ensures there are no conflict of interests or preferences and selection of articles is purely on its clinical content merit, thus ensuring best ethical standards and practices of peer-review are maintained.

Videos

Revista Brasileira de Ortopedia (RBO) encourages video submissions to complement its articles. Professional quality is expected and can be obtained by using easily available equipment without the need of a professional team.

All videos must have a slide with title, authors and possible conflict of interests. The nature and purpose of the video must be clearly stated, and it must have clear and understandable narration. All videos will be submitted to a peer-review.

The same ethics standards used in Revista Brasileira de Ortopedia for studies with human and animals are valid for the video archives to be submitted. Avoid incluiding institucional industry or any other type of marketing information or displaying a logo. Just as figures, videos must be cited in the manuscript (for example, "Video 1").

The following formats are acceptable: *.avi, *.mov, and *.mp4

Instructions:

- The length of the video cannot exceed 4 minutes;
- Sent only one video per article and not a multipart video;
- The video archive cannot exceed 150 MB;
- Narration is mandatory and can be made in Portuguese or English;
- The videos must be attached to the submission system, choosing *Dataset* the option in the *file upload menu.*

Supplementary Material

Supplementary material such as applications, images and podcasts can be published with your article to enhance it. The submitted material is published just as provided. Please send your supplementary material along with the article and provide a concise description for each item. If you wish to change the supplementary material, please provide the updated file.

Figure Captions

- Figures include photographs or radiographs, drawings, graphs, bar charts, flow charts, and pathways, but NOT lists or tables.
- Figures must be cited sequentially in the text. Number all figures (and corresponding figure captions) sequentially in the order they are cited in the text.
- Figure captions should be written after the reference list. Insert a page break between the end of references and the start of figure captions.
- Figure captions should include a description of the figure and/or each lettered part (A, B, etc.) and of any portions of the figure highlighted by arrows, arrowheads, asterisks, etc.
- For a figure borrowed or adapted from another publication (used with permission), add a credit line in parentheses at the end of each figure legend. This credit line should be a complete bibliographic listing of the source publication (as a reference), or other credit line as supplied by the copyright holder. For example (Reprinted with permission from Calfee DR, Wispelwey B. Brain abscess. Semin Neurol 2000;20:357.)

Tables

- Data given in tables should be commented on but not repeated in the text. Be sure that lists or columns of related data are composed in a word-processing program like the rest of the text.
- Do not intersperse tables in the text. Tables should appear after the figure captions. Insert a page break between the end of the figure captions and the start of the tables.
- Tables must be double-spaced and numbered in the same sequence they are cited in the text. A short descriptive title should be provided for each table.
- If a table contains artwork, supply the artwork separately as a digital file.
- For tables borrowed or adapted from another publication (used with permission), add a credit line as the first footnote beneath each table. This credit line should be a complete bibliographical listing of the source publication (as a reference), or other credit line as supplied by the copyright holder. For example, "Reprinted with permission from Calfee DR, Wispelwey B. Brain abscess. Semin Neurol 2000;20:357." ("Data from . . ." or "Adapted from . . ." may also be used, as appropriate.)
- Other footnotes for tables should be indicated in the table using superscript letters in alphabetical order.
- Any abbreviations used in the table should be explained at the end of the table in a footnote.

References

References must be as recent as possible and relevant to the available literature. It is essencial that they are complete and thoroughly checked. If the reference provided is incomplete, good search options are National Library of Medicine: www.nlm.nih.gov; Books in Print: www.booksinprint.com; Pub-Med: www.ncbi.nlm.nih.gov/PubMed/; or the publishers website.

- Must be listed in AMA style, using the Index Medical journal title abbreviation.
- Must come at the end of the text. Open a line before listing references.
- Must be cited sequencially in the text in numerical order (not alphabetical).
- Cite all authors up to the sixth author. If there are more than 6 authors, cite the first 3 followed by et al.
- Must follow the style as shown in the following examples:

1. Citing a journal article:

Borges JLP, Milani C, Kuwajima SS, Laredo Filho J. Tratamento da luxação congênita de quadril com suspensório de Pavlik e monitorização ultra-sonográfica. Rev Bras Ortop 2002;37(1/2):5–12

2. Citing a chapter in a book:

Johnson KA. Posterior tibial tendon. In: Baxter D. The foot and ankle in sport. St Louis: Mosby; 1995. p. 43–51

3. Citing a book:

Baxter D. The foot and ankle in sport. St Louis: Mosby; 1995

4. Citing a thesis:

Laredo Filho J. Contribuição ao estudo clínico-estatístico e genealógico-estatístico do pé torto congênito equinovaro [thesis]. São Paulo: Universidade Federal de São Paulo colocar virgula Escola Paulista de Medicina; 1968

5. Citing a government publication:

Food and Drug Administration. Jin Bu Huan Herbal Tablets. Rockville, MD: National Press Office; April 15,

1994. Talk Paper T94-22

6. Citing na online article:

Lino Junior W, Belangero WD. Efeito do Hólmio YAG laser (Ho: YAG) sobre o tendão patelar de ratos após 12 e 24 semanas de seguimento. Acta Ortop Bras [periodical on the Internet] 2005 [cited 2005, Aug 27];13(2):[about 5 p.] Available from: http://www.scielo.br/ scielo

7. Citing a symposium article:

Eisenberg J. Market forces and physician workforce reform: why they may not work. Paper presented at: Annual Meeting of the Association of American Medical Colleges; October 28, 1995; Washington, DC

DIGITAL ARTWORK PREPARATION

General Guidelines

- It is best to use Adobe Photoshop to create and save images, and Adobe Illustrator for line art and labels.
- Do not submit art created in Microsoft Excel, Word, or PowerPoint. These files cannot be used by the typesetter.
- Save each figure in a separate file.
- Do not compress files.
- All black-and-white and color artwork should be at a resolution of 300 dpi (dots per inch) in TIFF format. Line art should be 1,200 dpi in EPS or TIFF format. Contact the Production Editor at Thieme if you are unsure of the final size.
- It is preferable for figures to be cropped to their final size (approximately 3½ inches for a single column and up to 7 inches for a double column), or larger, and in the correct orientation. If art is submitted smaller and then has to be enlarged, its resolution (dpi) and clarity will decrease.

  Note: Lower resolutions (less than 300 dpi) and JPEG format (.jpg extension) for grayscale and color artwork are strongly discouraged due to the poor quality they yield in printing, which requires 300 dpi resolution for sharp, clear, detailed images. JPEG format, by definition, is a lower resolution (compressed) format designed for quick upload on computer screens.

Black-and-White Art

- Black-and-white artwork can be halftone (or grayscale) photographs, radiographs, drawings, line art, graphs, and flowcharts. Thieme will only accept digital artwork.
- If possible, do not send color art for conversion to black-and-white. Do the conversion yourself so that you can check the results and confirm in advance that no critical details are lost or obscured by the change to black-and-white.
- For best results, line art should be black on a white background. Lines and type should be clean and evenly dark. Avoid screens or cross-hatching, as they can darken or be uneven in printing and lead to unacceptable printing quality.

Color Art

- All color artwork should be saved in CMYK, not RGB.

Art Labels

- Arrows, asterisks, and arrowheads (or other markers) should be white in dark or black areas and black in light or white areas, and large in size. If not, these highlighting marks may become difficult to see when figures are reduced in size during the typesetting process.
- Use 1-point (or thicker) rules and leader lines.
- Capitalize the first word of each label and all proper nouns. Consider using all capitals if you need a higher level of labels.
- Where there are alternate terms or spellings for a named structure, use the most common one and make sure it is consistent with what is used in the text.
- Avoid using multiple fonts and font sizes for the labels; use only one or two sizes of a serif font.

SUBMISSION PROCEDURE

Article Processing Charge (APC) & Open Access

All papers in the Revista Brasileira de Ortopedia are published open access and are available online immediately upon publication without registration. All article processing charges (APCs) are fully sponsored by the Brazilian Society of Orthopaedics and Traumatology (Sociedade Brasileira de Ortopedia e Traumatologia SBOT). Upon acceptance, no APC is due by the author. No additional fees, including submission fees, editorial processing charges, or page and color charges apply. For current prices, please visit Open Access - Journal authors - Thieme Group, navigate to “APC”, and select the Price List. APCs are regularly reviewed and may be subject to change.

Submission Procedure

- Consult the checklist on the first page of this document to ensure that you are ready to submit your manuscript.
- Manuscripts must be submitted electronically at the following link: http://www.editorialmanager.com/rbo
- Always review your manuscript before submitting it. You may stop a submission at any phase and save it to submit later. After submission, you will receive a confirmation email. You can also check the status of your manuscript by logging in to the submission system. The system converts your article files to a single PDF file used in the peer-review process. Editable files are required to typeset your article for final publication. All correspondence, including notification of the Editor’s decision and requests for revision, is sent by e-mail. The Editor in Chief will inform you via email once a decision has been made.

Revision Procedure

The journal follows a double-blind peer-review process where neither author and reviewer does not get to know the identity of each other. At least two reviewers randomly selected based on their knowledge and experience under the supervision of the Editor-in-Chief on each manuscript. The decision is taken based on the comparative reviews that the manuscript receives during the review process.

- If the editor and reviewers conclude that your article needs revision, you will have to make the changes via a word-processing program and resubmit it electronically.
- Log In to the submission system and find your article, which will be marked for revision.
- The best way to make revisions to your manuscript is by enabling the Track Changes mode in Microsoft Word, which will automatically highlight and mark up revised text. Please submit both a marked up copy and a clean copy of your revised manuscript to the submission system.
- Your original files will still be available after you upload your revised manuscript, so you should delete any redundant files before completing the submission.
- You will also be provided space in which to respond to the reviewers' and editors' comments. Please be as specific as possible in your response.

PRODUCTION PROCEDURE

Page Proofs

Page proofs will be sent to you via email. The proofs will be in a PDF file format, which should be opened using Acrobat Reader software. You will receive further instructions with your proofs. Take this opportunity to check the typeset text for typographic and related errors. Elective alterations are difficult to accommodate owing to the associated time and expense of introducing them. Therefore, please be sure that when you submit your manuscript, it is accurate, complete, and final.

POLICY STATEMENTS

Privacy Statement

The names and email addresses entered in this journal site will be used exclusively for the stated purposes of this journal and will not be made available for any other purpose or to any other party.

Preprint Server Statement

RBO encourages the submission of manuscripts that have been deposited in an initial draft version in preprint repositories such as Research Square, arXiv, and medRxiv. Drafts of short conference abstracts or degree theses posted on the website of the degree-granting institution, and draft manuscripts deposited on authors' or institutional websites are also welcome. All other prior publication is forbidden.

During submission, authors should:

(1) note use of the preprint repository in the cover letter;

(2) state what adjustments and/or updates the draft has undergone between deposition and submission;

(3) cite the preprint, including the DOI, as a reference in the manuscript.

After submission to the journal, and until a final decision has been made, authors are discouraged from depositing versions of their manuscript as preprints. Upon publication authors should add a link from the preprint to the published article. Twelve months after publication, authors can update the preprint with the accepted manuscript.

Ethics standards

No data or image identifying a patient can be used without formal consent (patient permissionforms are available at: www.thieme.com/journal-authors); studies using human beings or animal trials must follow ethical standards from the International Committee of Medical Journals Editors – ICMJE, as well as approval of original institution's Ethics Committee; conflicts of interest must have a ICMJE form filled in by all authors (available at: http://icmje.org/); commercial marks should be avoided; authors are the sole responsible for opinions and concepts in the published articles, as well as for the reference accuracy. You may find the full Ethical Review Committee Statement here: https://cdn0.scrvt.com/9ca5761af4a1cf7bf49dd51537e8f4d1/0cd6b9200990aeae/c93e0c087bf4/Ethical_Review_Committee_Statement_form.pdf

Authorization Letter

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