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Treatment for Knee Flexion Contracture in Cerebral Palsy

Tratamiento de la contractura en flexión de rodilla en parálisis cerebral

Gino Martinez[1] Javier Segovia[2] Martín Cariola[1]

[1] Clínica Universidad de los Andes, Las Condes, Santiago, Chile
[2] Instituto Teletón, Santiago, Chile

Address for correspondence Gino Martinez, MD, Clínica Universidad de Los Andes, Avenida Plaza 2501, Las Condes, Santiago, Chile (e-mail: ginomartinez@gmail.com).

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Abstract

Full knee extension is essential for gait. Patients with cerebral palsy frequently have extension deficits of different magnitudes, which compromise walking and even standing up. The treatment of knee flexion contracture begins by addressing the spasticity of the involved muscles and includes physical therapy. For structured extension deficits, the treatment is surgical, using different techniques depending on the magnitude of the contracture and the patient's age. Soft tissue techniques include functional hamstring lengthening and muscle transfers. For capsular contracture, bone surgery is preferable and extends the proximal femur either progressively, through anterior physiodesis in pediatric patients, or acutely, by extensor distal femoral osteotomy. A high patella is common and requires correction during the same surgical procedure to maintain the efficiency of the extensor apparatus.

Keywords
- cerebral palsy
- knee
- contracture
- gait
- diplegia
- hamstrings
- high patella

Resumen

La extensión completa de la rodilla es esencial para la marcha. Los pacientes con parálisis cerebral infantil con frecuencia pueden tener déficit de extensión de distinta magnitud, lo que compromete la marcha e incluso la bipedestación. El tratamiento de la contractura en flexión de rodilla parte por tratar la espasticidad de los músculos comprometidos y con fisioterapia. Cuando el flexo es estructurado, el tratamiento es quirúrgico mediante distintas técnicas, dependiendo de la magnitud de la contractura y de la edad del paciente. Las técnicas sobre partes blandas incluyen alargamientos funcionales de isquiotibiales y transferencias musculares. Cuando la contractura es capsular, es preferible realizar cirugía ósea, la cual extiende el fémur proximal, ya sea en forma progresiva, mediante fisiodesis anterior en pacientes pediátricos, o en forma aguda, mediante osteotomía extensora del fémur distal. Con frecuencia existe una patela alta, la cual hay que corregir en el mismo acto quirúrgico para mantener la eficiencia del aparato extensor.

Palabras clave
- parálisis cerebral
- rodilla
- contractura
- marcha
- diplejía
- isquiotibiales
- patela alta

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Introduction

Knee extension during walking is critical for the initial contact phase and single-leg midstance when passive extension results from the second rocker of the ankle and it is blocked in extension, conserving energy and maintaining limb stability to support the entire body weight.[1,2] It is critical that the ground reaction force at such a stage passes in front of the knee to achieve this passive extensor effect, as well as the adequate action of the soleus to block the anterior translation of the tibia and enable knee extension. A ground reaction force vector passing behind the knee tends to bend it even more in single-leg loading, generating higher flexion and, as a result, a co-contraction of the permanent extensor apparatus. This co-contraction stresses the patella and elongates the patellar tendon, leading to secondary high patella and insufficiency of the extensor apparatus (►**Figure 1**).[1,2]

Knee flexion in cerebral palsy may originate primarily from muscle spasticity, especially in the hamstring group. Secondarily, the muscles shorten, and capsular retractions occur, leading to structured knee flexion. Tertiarily, knee flexion may compensate other lower extremity deformities, such as club foot, limb length discrepancy, or hip flexion, which is common in these patients.[3–8]

In the clinical evaluation, it is fundamental to verify the patient's degree of spasticity according to the Ashworth scale. The popliteal angle will determine the clinical length of the hamstrings, which is normally lower than 40°. It is also critical to measure it with the pelvis level by bending the contralateral hip to avoid the effect of anterior pelvic tilt on the hamstrings (bilateral popliteal angle) (►**Figure 2**). The knee extension deficit is determined with the patient in the supine position, with 0° to 5° of hyperextension being normal. It is also important to determine the sufficiency of the extensor apparatus through the extensor lag or the difference in degrees between active and passive extension (►**Figure 3**). One must not forget to check the influence of other joints on the knee, especially if there is structured hip flexion or equinus deformity of the ankle.[9]

Gait analysis enables the determination of the kinematic profile of the knee in permanent flexion and the length of the hamstrings to define if their lengthening is required. This analysis also shows the kinematics of adjacent joints, especially in the pelvis, as well as ankle position (►**Figure 4**).[9,10]

As for classification, we will refer to knee flexion in diplegia, which accounts for most issues, and the classification of the evolution of Roda's diplegic gait (►**Figure 5**). A knee jumping during complete extension and flexion results from spasticity, which requires treatment. However, flexion is more structured in advanced stages, and its treatment is direct.[2]

Fig. 1 Lateral knee radiograph from a patient with high patella.

Treatment

For flexion due to primary alterations, the spasticity requires pharmacological treatment with the administration of botulinum toxin in the hamstrings or surgical selective dorsal rhizotomy. Physical therapy and orthotic treatment help align the limb and keep the knee in extension. Treatment of secondary alterations, including muscle shortening and structured deformities, uses different surgical techniques, such as, hamstring lengthening or transfer, distal femoral extensor osteotomy, and anterior physiodesis of the distal femur. The resolution of tertiary alterations relies on correcting the alteration of the adjacent joint, such as management of the equinus deformity, hip flexion, and limb dysmetria.[11]

Regarding surgical treatment, particularly for secondary alterations (muscle and capsular retractions), always consider first treating spasticity and correcting adjacent segments and associated skeletal deformities, often in the context of multilevel surgery. Do not overcorrect, since knee overcorrections may be very difficult to solve. Therefore, apply the concept of "surgical dose" and consider the skeletal maturity and degree of functionality of the patient.

Hamstring Surgery

Isolated hamstring surgery is usually indicated for mild to moderate structured flexions ranging from 5° to 20°, with a popliteal angle greater than 60°. These values reveal an actual shortening of the hamstrings, which can be demonstrated by the gait laboratory. An important concept is that, in the presence of an anterior pelvic tilt, hamstring lengthening is not recommended, since it generates a higher anterior tilt (because the hamstrings are fundamentally hip extensors and pelvic retroverters) (►**Figure 6**). An overcorrection may lead to recurvatum of the knee, whose treatment is a challenge.

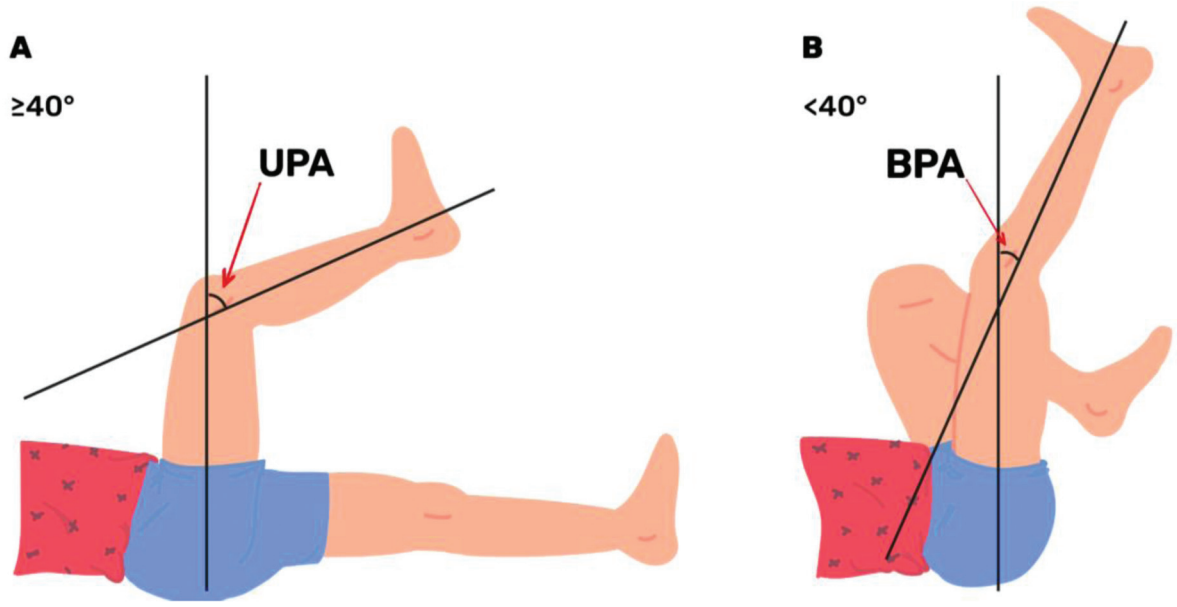

Fig. 2 The evaluation of the relationship between the hamstrings and pelvic tilt is based on the difference between the unilateral popliteal angle (UPA) and the bilateral popliteal angle (BPA). (**A**) Unilateral popliteal angle: examined hip in 90° of flexion and contralateral knee in extension. Record the missing degrees for full extension of the tested knee. This angle represents the functional shortening of the hamstrings, affected by anterior pelvic tilt. (**B**) Bilateral popliteal angle: Flex the contralateral hip until the anterosuperior and posterosuperior iliac spines are vertically aligned (correction of pelvic anteversion and lumbar lordosis). Record the missing degrees for the full knee extension tested. This angle represents the ACTUAL shortening of the hamstrings.

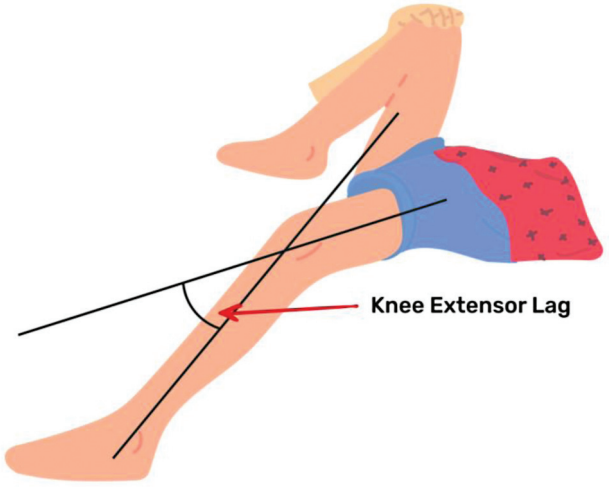

Fig. 3 The extensor lag evaluates the insufficiency of the knee extensor apparatus. In a supine position, with the contralateral foot resting on the stretcher, ask the patient to maximally extend the examined knee and record the degrees of extension deficit. Then, passively extend the knee and record the degrees of passive extension deficit. The difference in degrees between active and passive extension is the extensor lag.

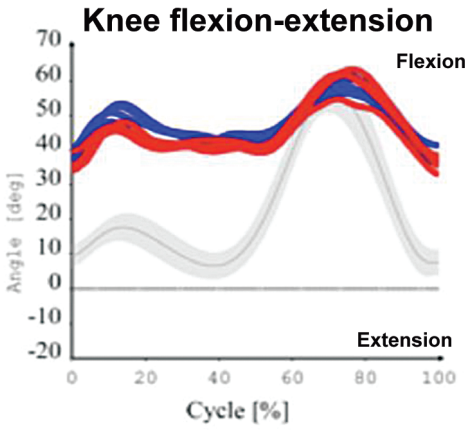

Fig. 4 The gait and movement laboratory study, in which we record knee kinematics during the gait cycle from a patient with bilateral structured knee flexion. The gray line corresponds to the normal angular movement of a knee.

When lengthening the hamstrings, it is often advisable to lengthen the medial muscles through muscle fasciotomies to preserve muscle strength. Never perform tenotomies at this level. This procedure is indicated for mild flexion ranging from 5° to 10° in highly-functional patients, classified as grades 1 to 3 in the gross motor function classification system (GMFCS). Avoid over-lengthening to avoid anterior pelvic tilt or recurvatum of the knee. Today, lengthening of the lateral knee region is no longer performed in functional patients due to the risk of overcorrection.[11–13]

Semitendinosus transfer to the adductor magnus is a technique to transform this muscle from biarticular to monoarticular, thereby removing its flexor function on the knee and maintaining its extensor function on the hip and pelvis (►**Figure 7**). However, its role in preventing anterior pelvic tilt is not clear. The procedure is indicated for flexions ranging from 10° to 20°, patients with a higher functional compromise (GMFCS grades 3 to 4), or more functional patients with more severe early flexion. This procedure can be added to others, such as anterior knee physiodesis in small or prepubertal patients.[11]

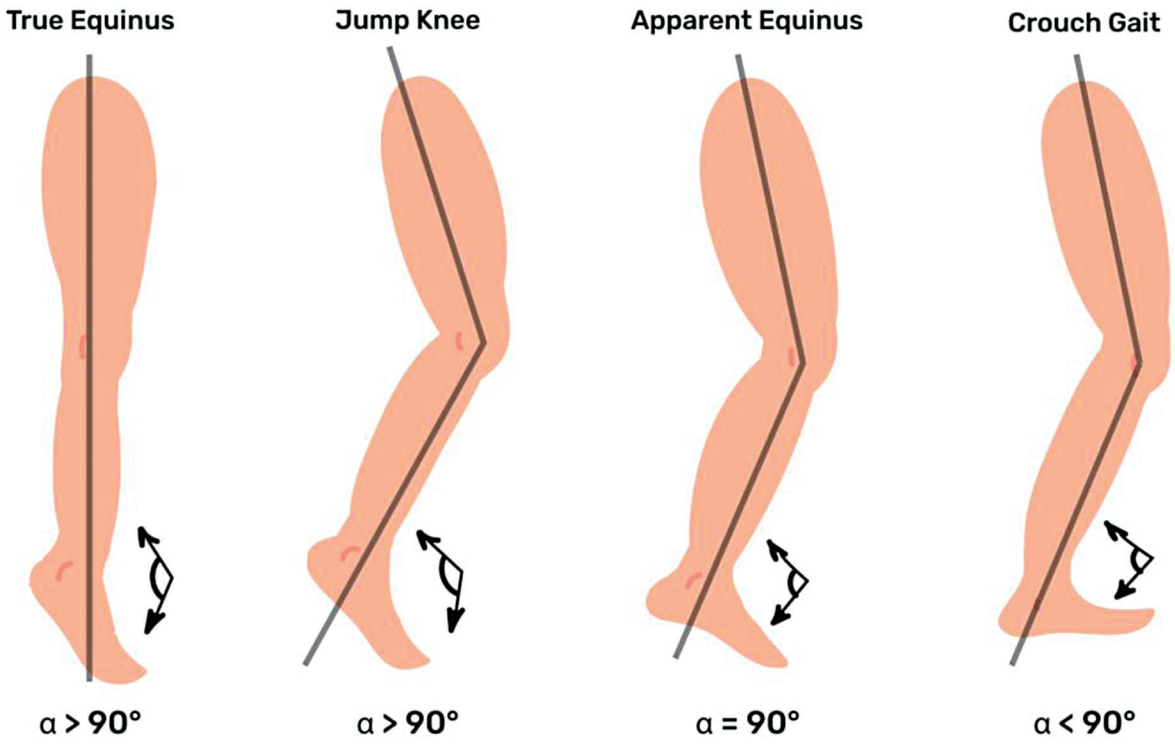

Fig. 5 Schematic representation of the gait evolution in the sagittal plane in diplegic patients according to Roda.

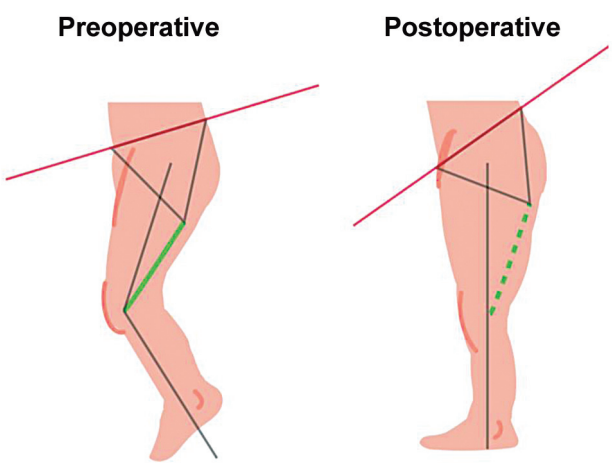

Fig. 6 Representation of the increase in anterior pelvic inclination during hamstring lengthening (in green).

Distal Femoral Extensor Osteotomy

Distal femoral extensor osteotomy is the gold standard for the definitive treatment of structured knee flexion in patients with flexion ranging from 10° to 40°, close to skeletal maturity (with fewer than 2 years of growth remaining) (►**Figure 8**). Lengthening the hamstrings after osteotomy is often not required, since extensor osteotomy tightens the hamstrings, preserving their hip extensor function. As a result, hamstring lengthening can produce overcorrection or anterior pelvic tilt.[14,15]

It is critical to consider patellar descent, which virtually always accompanies the extensor osteotomy due to the insufficiency of the extensor apparatus and the high patella presented by these patients.[15–18]

Subjects with more severe flexion (> 40°), in addition to the extensor osteotomy, can undergo femoral shortening to generate a precarious standing position or gait, with supplementary optional hamstring lengthening and regular patellar descent.[3,19]

Anterior Physiodesis of the Distal Femur

This procedure became very popular in patients with an immature skeleton (fewer than two years of growth remaining), obviously, as it generates a progressive extension of the knee at the level of the distal femoral physis. It is indicated for flexion ranging from 10° to 30°, and it may include a supplementary hamstring lengthening or transfer. Among the different techniques, screws have shown advantages over figure-eight plates or anterior tension bands, since they present fewer local complications and lower levels of postoperative pain and stiffness. As a result, screws enable early mobilization with similar correction rates, being currently recommended for knee flexion in patients with an immature skeleton (►**Figure 9**).[20–23]

Final Considerations

Knee flexion is a common alteration in patients with childhood cerebral palsy. Always consider treating spasticity first.

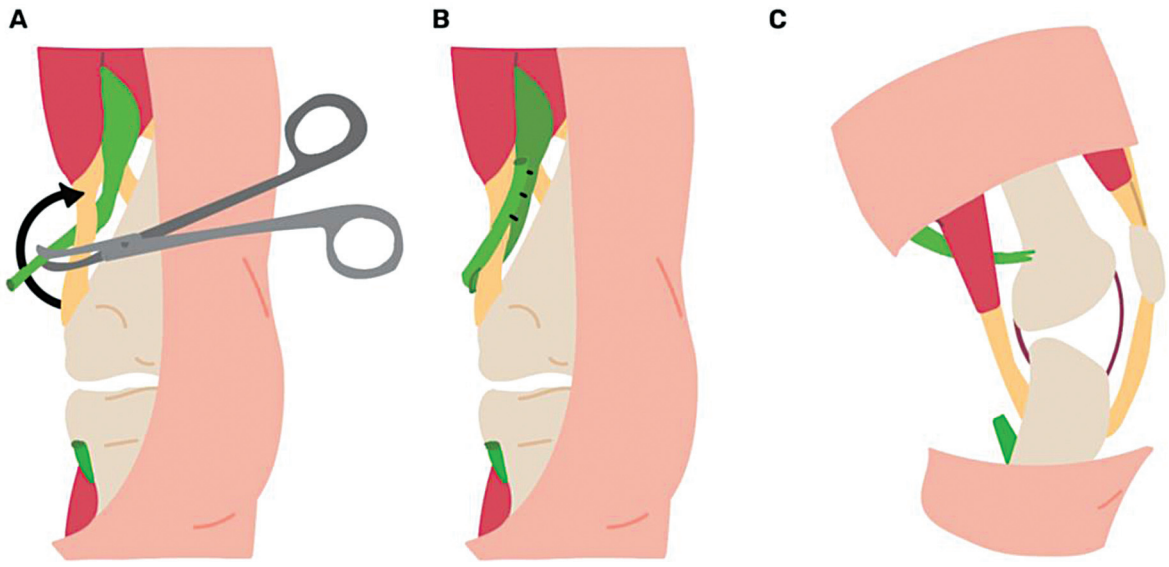

Fig. 7 Transfer of the semitendinosus to the adductor magnus tendon. (**A**) Distal release of the semitendinosus. (**B**) Suture of the semitendinosus to the adductor magnus tendon passing through it. (**C**) Diagram of the transfer in the sagittal plane. The semitendinosus goes from a knee flexor to a pure hip extensor.

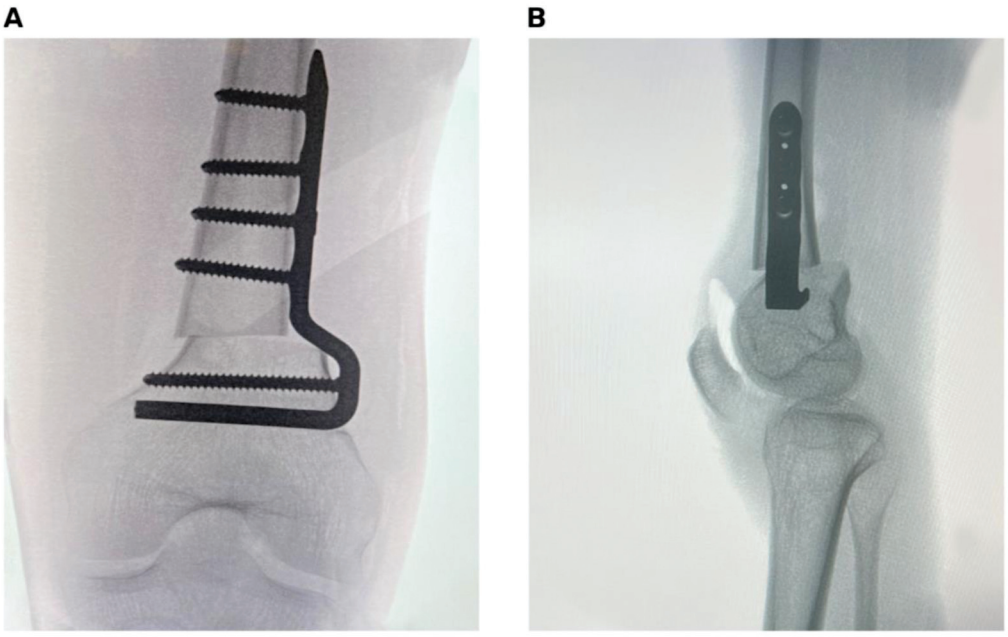

Fig. 8 Distal femoral extensor osteotomy with fixed angle blade plate. (**A**) Intraoperative anteroposterior radiograph. (**B**) Intraoperative lateral radiograph showing the extension of the distal femur plus the respective patellar descent.

In addition, consider the correction of compromised adjacent segments (hip, foot, and ankle). Consider hamstring lengthening (with or without transfer) in patients with mild to moderate flexion but no anterior pelvic tilt.

Distal femoral extensor osteotomy is the gold standard to definitively correct flexion in patients close to skeletal maturity, virtually always adding patellar descent. Anterior physiodesis of the distal femur is indicated in prepubertal patients with mild to moderate flexion, almost always accompanied by a soft tissue procedure. Avoid overcorrecting and consider the previous functional capacity of each patient.

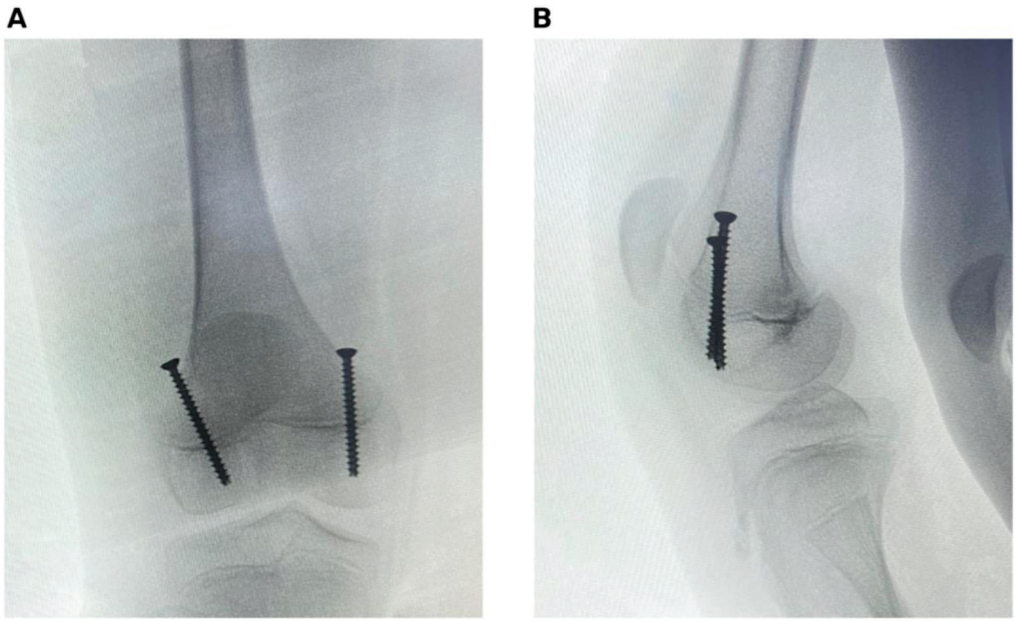

Fig. 9 Anterior hemiepiphysiodesis of the distal femur with two percutaneous cannulated screws (**A**) Intraoperative anteroposterior radiograph. (**B**) Intraoperative lateral radiograph.

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