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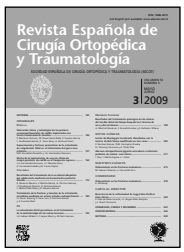

ORIGINAL PAPERS

Survivorship and prognostic factors of high tibial osteotomy in the treatment of arthritic genu varum

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KEYWORDS
Genu varum;
Survival;
Tibial osteotomy;
Tibial slope;
Osteoarthritis

Abstract
Purpose: The purpose of this study was to analyze the survivorship of high tibial osteotomy in the treatment of arthritis genu varum, as well as to correlate the degree of arthritis, the tibiofemoral angle and the tibial slope with the reappearance of pain.
Materials and methods: We retrospectively studied 80 knees (44 right and 36 left ones) in 73 patients (21 males and 52 females) with a mean age of 61 years (range: 42-82 years) who had been subjected to a Coventry-type high tibial osteotomy between January 1994 and December 1998. Mean follow-up was 88 months (range: 16-137).
Results: After 5-10 years no prosthesis was implanted in 89.35%/61.15% of patients respectively, but only 63.75%/45.74%were pain-free. Patients with a higher preoperative Ahlbäck score tended not to complain of postsurgical pain. No correlation was found between the tibiofemoral angle and the appearance of pain. After the osteotomy, the tibial slope was usually gentler and patients who postoperatively presented with tibial slope anteversion experienced pain earlier, these findings being statistically significant.
Conclusions: High tibial osteotomy is a useful surgical approach that can defer the need for a knee prosthesis in a high percentage of patients. Nonetheless, a meticulous technique is essential to avoid postoperative anteversion of the tibial slope, a complication that favors the early onset of pain.

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PALABRAS CLAVE
Genu varo;
Supervivencia;
Osteotoía tibial;
Pendiente tibial;
Artrosis

Supervivencia y factores pronósticos de la osteotomía de valguización tibial en el tratamiento del genu varo artrósico

Resumen
Objetivo: El objetivo de este trabajo fue analizar la supervivencia de la osteotomía de valguización tibial (OVT) en el tratamiento del genu varo artrósico, así como correlacionar el grado de artrosis, el ángulo femorotibial y la pendiente tibial con la reaparición de dolor.
Material y método: Se estudiaron retrospectivamente 80 rodillas de 73 sujetos (44 rodillas derechas y 36 rodillas izquierdas, en 21 varones y 52 mujeres) con una edad media de 61 años (rango de 42 a 82), a las que se les había realizado una OVT supratuberositaria de sustracción tipo Coventry entre enero de 1994 y diciembre de 1998. El tiempo de seguimiento medio fue de 88 meses (rango de 16 a 137).
Resultados: Tras 5 y 10 años no se había implantado una prótesis en el 89,35 y el 61,15% de los sujetos, respectivamente, pero sólo el 63,75 y el 45,74% estaban libres de dolor. Los sujetos con grado de Ahlbäck preoperatorio más avanzado tenían tendencia a no presentar dolor postquirúrgico. No se encontró ninguna correlación entre el ángulo femorotibial y la aparición de dolor. Tras la osteotomía, la pendiente tibial disminuyó y los sujetos que en el postoperatorio presentaban anteversión de la pendiente tibial presentaron dolor más precozmente; siendo estos hallazgos estadísticamente significativos.
Conclusiones: La OVT es una técnica quirúrgica útil que retrasa la necesidad de una prótesis de rodilla en un porcentaje elevado de sujetos. No obstante, obliga a una técnica meticulosa para evitar la anteversión posquirúrgica de la pendiente tibial, defecto que favorece la aparición precoz de dolor.

Introduction

High tibial osteotomy (HTO) is a surgical technique indicated to relieve pain and improve function in subjects with medial tibiofemoral arthritis and varus deformity.

The high percentage of good results obtained with total knee replacement (TKR), the patients' of reproducible results and the realization that TKR implantation following a tibial osteotomy leads to a higher complications rate[1] has resulted in a decrease in the number of osteotomies performed and a consequent increase in TKR procedures in Canada and the United States in the last few years[2]. This trend also manifests itself in Spain and is associated to important consequences for the treatment of patients and the Management of healthcare budgets.

HTO provides satisfactory results in 50 to 95%of subjects after 5 years and in 28 to 92%of subjects after 10 years[3-10]. When evaluating survivorship, HTO is considered to have failed when a TKR needs to be implanted rather than when pain reappears since the latter situation is more imprecise and occurs sooner.

The literature is inconclusive[3,10,11] as regards the prognostic factors related to the outcome of HTO. Although scholars have addressed the effect of osteotomy on tibial slope[12], and it has been observed that the tibial slope tends to increase after an opening wedge osteotomy[13-16] and to decrease following a closing-wedge osteotomy[12,17], no studies have been published that correlates post-surgical tibial slope with the success of the technique.

The purpose of this study was to evaluate survivorship of HTO against such criteria as reappearance of pain, inclusion of the subject in a waiting-list and implantation of a TKR, as well as to correlate the degree of preoperative tibiofemoral arthritis, el tibiofemoral angle and pre- and postoperative tibial slope with reappearance of pain.

Materials and methods

Retrospective study of 73 subjects (7 with bilateral surgery), 21 males and 52 females, with a mean age of 61 years (range: 42-82). These patients had undergone a Coventry-type high tibial osteotomy (80 knees, 44 on the right side and 36 on the left side) between January 1994 and December 1998. All the subjects developed primary medial compartment arthritis with varus deformity. Patients with inflammatory or post-traumatic arthritis had been excluded previously.

Pre- and post- operative weightbearing anteroposterior knee x-rays were used to determine the severity of OA on Ahlbäck's scale. Absence of radiologic arthritic signs was rated as grade 0; joint space reduction (with or without subchondral sclerosis) was rated as grade i, joint space obliteration was rates as grade ii, a bone defect of less than 5 mm was rated as grade iii, a bone defect between 5 and 10 mm was rated as grade iv and a bone defect larger than 10 mm (normally associated to subluxation and lateral compartment arthritis) was rated as grade v.

The procedure was carried out under general or spinal anesthesia, with the subject in the supine position, limb ischemia and the knee flexed at 90°. The proximal tibiofibular joint was taken down in all cases and a bone

wedge was resected from the tibial metaphysis (proximal to the anterior tibial tuberosity); the space of the osteotomy was closed and stabilized with one or two stepped staples. Postoperatively, the limb was immobilized with a long-leg cast: `progressive weight-bearing was authorized as tolerated, with the cast being removed when radiographic healing signs appeared. At that moment, joint mobility was begun. Mean follow-up was 88 months (range: 16-137); follow-up was considered over for those subjects where a TKR was implanted.

From the patients' medical record we obtained the date when pain appeared following osteotomy, the date the patients were included in the waiting-list for TKR implantation and the date at which the arthroplasty was performed. Subjects were divided into 3 clinical groups depending on the time at which the first painful symptoms began: group 1 was made up of 39 patients who experienced no pain at the time the study was concluded and who had been followed up for a minimum of 4 years; group 2 was made up of 17 subjects who experienced pain at 4 months from osteotomy and group 3, was made up of subjects who presented with pain within 4 years post-op. The 4-year figure was chosen as a cut-off point because an osteotomy is normally considered to have failed when it is converted to a TKR before 5 years[1,9].

In the (non-weightbearing) anteroposterior x-rays performed in the immediate post-op period, in those performed after 6-8 months (weightbearing) and in those carried out at the end of follow-up (weightbearing), a determination was made of the anatomic tibiofemoral angle, formed by the femoral and tibial diaphyseal axes[3,18,19] (fig. 1A). In the corresponding lateral x-rays, we measured the posterior tibial slope, defined as the angle formed by the tangent to the surface of the medial articulating facet of the tibia and the proximal tibial diaphyseal axis[20] (fig. 1B); when this angle increases, the tibial articular surface is anteverted, which results in a decrease of the posterior tibial slope; when the angle decreases, a retroversion of the tibial articular surface occurs, which is equivalent to an increase in the posterior tibial slope.

All the measurements were made by one of the authors, who did not participate in the surgery and who was not au fait with the clinical result.

A descriptive statistical analysis was made of each of the variables. The Kaplan-Meier method was used for survivorship analyses and 3 different assessment criteria were used: the point at which pain appeared, the date when patients were included in the waiting list and the date of implantation of the TKR. The correlation between Ahlbäck's score for preoperative tibiofemoral arthritis and the onset of pain was calculated by means of the χ^2. test. The influence of variations in the tibiofemoral anatomic axis and in posterior tibial slope on pain was studied through a variance analysis. Spearman's rank correlation coefficient was used to study the relationship between the tibiofemoral angle and postoperative tibial slope. In addition, a value of $p<0.05$ was taken as statistically significant.

Results

The 5-year survivorship rate of the tibial osteotomy was 63.75, 79.52 and 89.35%, when reappearance of pain, inclusion in waiting-lists and TKR implantation, respectively, were considered as assessment criteria. At 10 years, these figures went down to 45.74, 47.79 and 61.15% of subjects (fig. 2).

The prevailing Ahlbäck score in the 3 clinical groups (without pain after 4 years, with pain after 4 years and with pain before 4 years) was higher preoperatively than in the last follow-up control. Before surgery, 73% of subjects in group 1, 62% of subjects in group 2 and 45% of subjects in

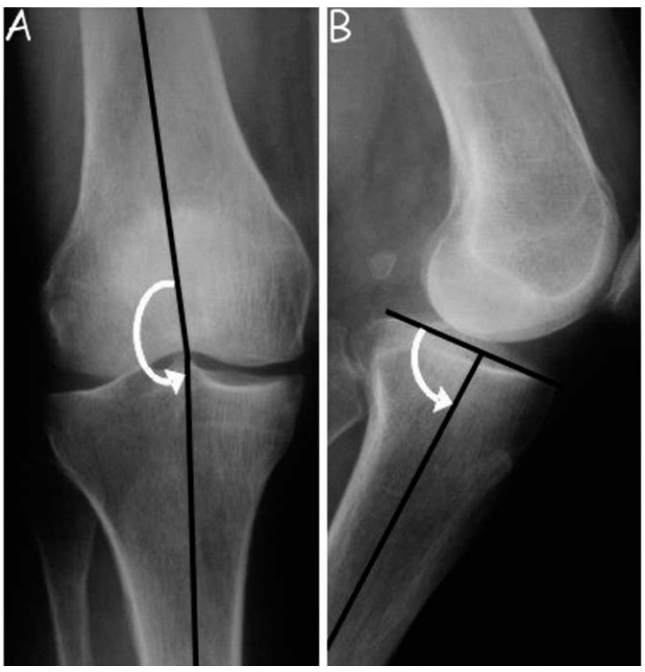

Figure 1 Radiographic measurement of the tibiofemoral angle and the tibial slope. A) Tibiofemoral angle. B) Tibial slope.

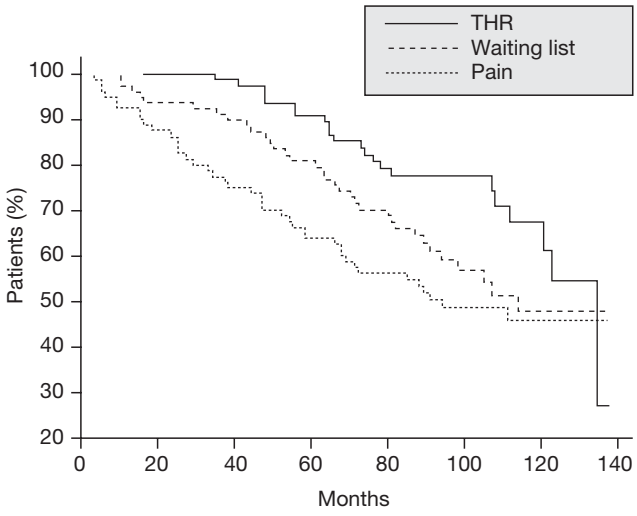

Figure 2 HTO survivorship curves. The assessment criteria are reappearance of pain, point of inclusion into a waiting-list and date of TKR implantation.

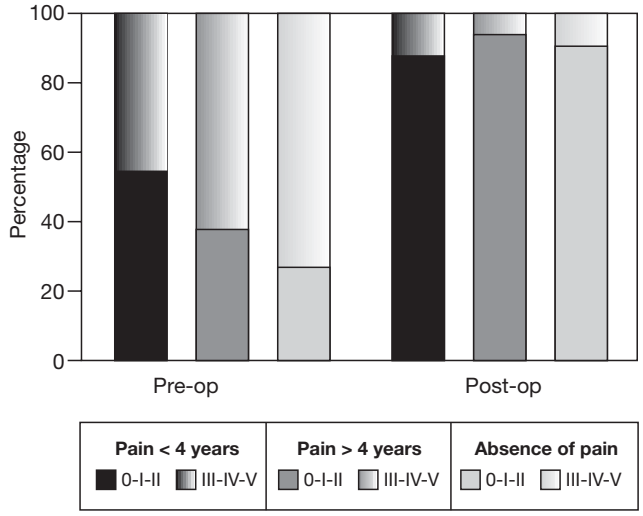

Figure 3 Pre- and postoperative Ahlbäck scores for clinical groups 1 (with pain before 4 years), 2 (pain after 4 years) and 3 (without pain throughout follow-up).

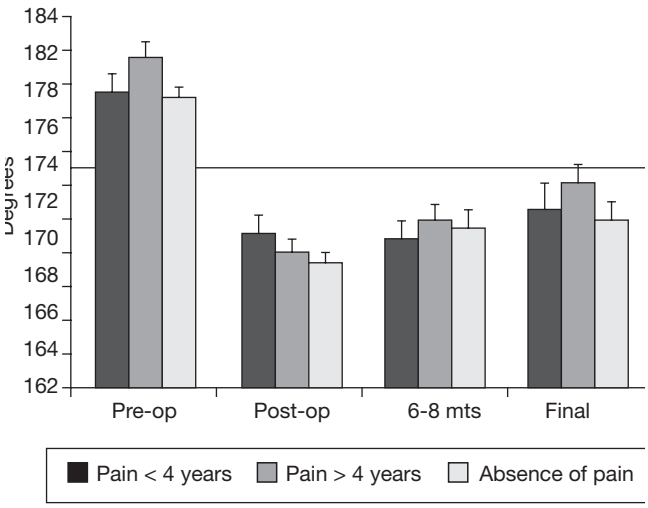

Figure 4 Tibiofemoral angle for clinical group 1 (con dolor antes de 4 years), 2 (pain after 4 years) y 3 (with no pain throughout follow-up).

group presented with Ahlbäck degrees iii, iv or v, but differences were not significant (fig. 3). After surgery, 80-90%of subjects presented with Ahlbäck degrees i, ii or iii, and differences were minimal across the clinical groups (fig. 3). Therefore, HTO did succeed in improving the patients' radiological arthritis status.

Tibiofemoral angle had a mean preoperative value of 179.83°± 4.31°, a mean immediate postoperative value of 170.09°±3.60° and a mean value at the end of follow-up of 172.66°±5.88°. In none of the study periods were significant differences detected for this angle between the 3 clinical groups (fig. 4).

Tibial slope had a mean preoperative value of 84.34°±4.39°, a mean immediate postoperative value of 87.58°± 4.76° and a mean value at the end of follow-up of 89.29°±6.05°. Therefore, tibial slope increased significantly from the immediate post-op period to until the last follow-up appointment ($p<0.05$), i.e., progressive anteversion of the tibial articular facet was observed (fig. 5).

During the pre-op period, there were no significant differences in tibial slope between group 1 (83.24°±3.87°), group 2 (85.50°± 365°) and group 3 (85.10°± 539°). Postoperatively, group 3 (with pain before 4 years) presented with a statistically significant decrease in tibial slope (in other words, a significant increase in anteversion) as compared with group 1 (without pain after 4 years), in the immediate post-op period (90.29°± 4.15° vis-à-vis 86.46°±5.03°), at 6-8 months' follow-up (90.87°±4.31° vis-à-vis 86.82°±4.84°) and at the last follow-up appointment (91.77°±4.85° vis-à-vis 87.13°±6.69°).

Group 2 (with pain after 4 years), an intermediate group both clinically and in terms of tibial slope, presented a gentler tibial slope (greater anteversion) than group 1, as well as a steeper slope (greater retroversion) than group 3, both in the immediate post-op period (88.59°±5.05°), at 6-8 months' follow-up (89.82°±4.73°) and at the last follow-up visit (90.19°±4.79°). However, these differences were not statistically significant (fig. 6).

No statistical correlation was found between the degree of correction achieved on the frontal plane (postoperative tibiofemoral angle) and the change in tibial slope brought about by surgery.

Discussion

HTO survivorship varies from one clinical series to the next: it stands between 50 and 95%at 5 years and between 28 and el 92%at 10 years[3,4,5,7-10,21] (table 1).

The literature offers contradictory conclusions[3,11] about the factors related to both outcome and survivorship of HTO. Factors related with a higher survivorship[3,11] include age under 60 years, pure unicompartmental involvement, ligament stability and minimum preoperative range of motion of 90°. Factors associated with early failure have also been described[3,10,11]: age over 70 years, an Ahlbäck score equal to or higher than grade iii, prior arthroscopic debridement, lateral tibial displacement during gait, insufficient valgus correction, postoperative flexion lower than 120° and body mass index below 25 kg/ m^2 (probably due to increased physical activity).

HTO survivorship will vary as a function of the criterion used to define failure. Pain is the first symptom that the technique has failed and, perhaps, the most sensitive parameter of all. For that reason, if the criterion for failure is reappearance of pain, survivorship will be lower[5]. Between the appearance of pain and inclusion on a waiting list or prosthetic implantation, a variable length of time elapses, many times extended because of problems inherent in waiting list Management. Therefore, use of these last parameters as failure criteria leads to a higher survivorship of HTO[9,10]. The results of the present series coincide with those in the literature and, depending on the failure criterion used for assessment, survivorship figures fluctuate between the higher and lower margins described.

Figure 5 Progression of tibial anteversion during follow-up. A) Pre-op. B) Immediate post-op (technical error resulting in infringement of the medial cortex when performing the osteotomy; hypercorrection). C) Between 6 and 8 months post-op. D) Last follow-up x-ray.

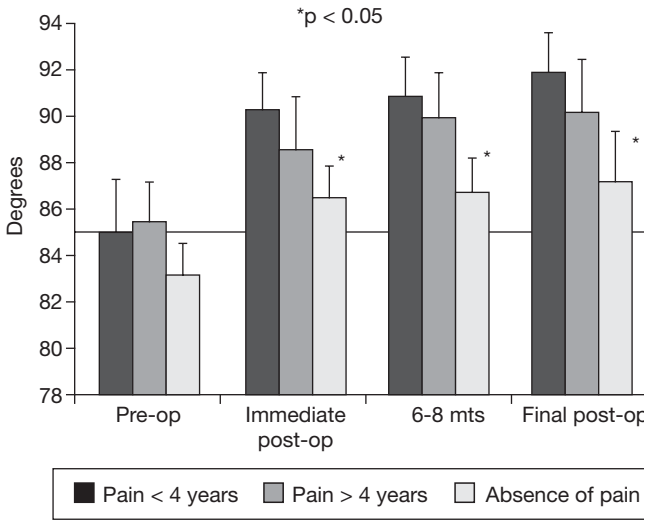

Figure 6 Clinical groups 1 (with pain before 4 years), 2 (pain after 4 years) and 3 (without pain throughout follow-up).

Table 1 Results in the literature for HTO survivorship in the treatment of arthritic genum valgum

Author (years)	Good results (%)	Follow-up
Coventry[7]	87–66	5–10
Insall[4,21]	64,7–63	5–8,5
Berman[3]	57	15
Rudan and Simurda[8]	70	10–15
Matthews[5]	50–28	5–9
Yasuda[9]	63	10
Flecher[10]	95–92–85	5–10–20

The degree of arthritis on Ahlbäck's scale improved after surgery; load transfer toward the lateral compartment caused by the change in the mechanical axis may have influenced this improvement. Another explication could be found in intra-observer variability in terms of radiograph interpretation.

Unlike other published series[4,6,10,22], ours shows that the higher the Ahlbäck score the better the subsequent clinical evolution[23]. Thus, group 1 (with no pain after 4 years) presented with a higher percentage of cases where the Ahlbäck score was equal to or higher than grade iii. The explanation to this could be that subjects with greater x-ray involvement have a poorer initial clinical status, for which reason the clinical improvement made possible by the operation is appreciated more subjectively.

Alignment of the lower limb on the frontal plane could be defined as a function of the mechanical axis[9,10,15,17] or of the anatomic tibiofemoral axis[1,7,11,22,24], although there are no studies that demonstrate which of these 2 angles is the more reproducible[25]. In our cases, the anatomic angle was used in a weightbearing x-ray rather than in a telegoniometry because the former is cheaper, easier to perform and affords similar intra-observer reproducibility and reliability[26].

As in other published series[4,6], the anatomic tibiofemoral angle was hypercorrected following osteotomy, with the deformity recurring over time, Albert without reaching the preoperative varus level.

No correlation was found between preoperative alignment, the degree of postoperative correction and subsequent clinical evolution; nor is there any consensus on this in the literature[10]. For Huang[22], preoperative varus over 9° worsens the osteotomy's result. In their turn, Rudan and Simurda[8] associate a good result to a postoperative tibiofemoral valgus of 6° to 14°, whereas Cass[27] obtains better results when postoperative valgus is higher than 10°.

La tibia presents with a triangle-shaped cross-section, which means that the osteotomy can introduce changes not only on the coronal but also on the sagittal plane. These changes on the sagittal plane seem to depend on the type of osteotomy carried out: opening-wedge osteotomy could lead to an increased tibial slope[13-16] whereas a Coventry-type osteotomy could reduce the tibial slope[12,17]. Alterations

on the sagittal plane following dome osteotomy are related to the degree of correction obtained on the frontal plane. Overcorrection favors a decrease in tibial slope; hypercorrection promotes an increase in tibial slope[28]. Nonetheless, as was the case in our own series, no correlation was found between the degree of correction on the frontal plane and the amount of postoperative tibial anteversion following Coventry-type osteotomy[12].

In line with the papers by Hohmann[12] and Brouwer[17], following the Coventry-type osteotomy we observed a progressive decrease in tibial slope (i.e., an anteversion of the joint surface). This decrease of the tibial slope (o anteversion) is more marked in subsequent x-rays and entails a deterioration with respect to the immediate post-op situation. It has been shown that the decrease in tibial slope could be due to an incomplete resection of the tibia's posterior cortex when the bone wedge is extracted, since this is done with care in order to prevent popliteal vascular or nerve lesions; it can also be due to the persistence of a posterolateral support for the tibiofibular syndesmosis[17].

Another possible explanation for the progressive decrease in tibial slope could be the lower resistance of the epiphyseal spongiosa (proximal segment), which supports the anterior and lateral cortex of the distal fragment[28,30]. The cancellous bone, known to be weaker, favors the progressive impact of the distal segment onto the anterior area when the subject bears weight (fig. 5). If we follow this hypoithesis, it may be possible to defer subsidence of the anterior cortex by delaying weightbearing, i.e, keeping the subject off weightbearing or putting him on partial weightbearing until the osteotomy has healed.

A third explanation for the gradual decrease in tibial slope correlates the ability to preserve postoperative alignment with the fixation system used[29,31,32]. Although we are not familiar with any study that analyzes this issue on the sagittal plane, an improvement in the stability of the fixation system could prevent the progression of tibial anteversion.

Final tibial slope is a very important prognostic factor for clinical outcome; decrease in final tibial slope or anteversion was related with a poor clinical result and early onset of pain (before 4 years), while a correct tibial slope (retroverted tibial articular surface) was correlated with absence of persistent pain. The change in tibial slope modifies knee kinematics as well as the forces acting on ligaments and joint surfaces[14], which could cause pain and trigger the progression of degenerative changes.

In addition, tibial anteversion could cause difficulties when implanting a knee prosthesis in the future (in the same way as valgus hypercorrection, patella infera or rotational alterations)[33]. In this connection, when performing the proximal tibial cut it is essential to take as a reference the posterior tibial surface. If the reference for the depth of the cut is established in the central or anterior regions, the cut will be too distal.

The main limitations of the present study are its retrospective design (we only considered pain and disregarded other functional parameters to calculate survivorship) y la intra-observer variability of radiographic measurements.

To conclude, in appropriate indications and with a meticulous surgical technique, Coventry-type HTO could be an effective treatment for arthritic genum varum since it relieves pain and defers prosthetic implantation in a high number of subjects. Although a large number of factors influence outcomes and survivorship, anteversion and postoperative reduction in tibial slope are signs of poor prognosis.

Conflict of interests

The authors have not received any financial support in the preparation of this article. Nor have they signed any agreement entitling them to receive benefits or fees from any commercial entity. Furthermore, no commercial entity has paid or will pay any sum to any foundation, educational institution or other non-profit-making organization to which they may be affiliated.

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