Fractures of the tibial pilon. Long-term functional results

Ó. Fernández-Hernández, I. Álvarez-Posadas, J. Betegón-Nicolás, J.J. González-Fernández and S. Sánchez-Herráez
Department of Orthopedic and Trauma Surgery. Hospital of León. León.

Purpose. This is a functional and epidemiological long-term study of tibial pilon fractures treated in our hospital over a five-year period. Our aim was to determine the long-term evolution of these fractures, to assess the potential effect of the quality of the reduction obtained and of the condition of the soft tissues on the final outcome and to evaluate the relationship between fracture type, radiographical degenerative signs and the results obtained.
Materials and methods. Ninety-one tibial pilon fractures were reviewed in 87 patients (4 bilateral ones), 29 of which were women (31.9%) and 62 men (68.1%). A retrospective study was carried out of all clinical records, further to which patients were called in to be evaluated with respect to the Duquennoy ankle scale and to have their parameters objectively assessed and their radiographs updated.
Results. On the Duquennoy scale, the factors most significantly affected by the fracture were the ability to run and to jump, with a mean value of 1.6/5 points and walking on uneven ground (2.6/5). The factors least affected by the injury were the need of a walking-stick (4.3/5) and the gait perimeter (8.4/10). There was a high incidence of initial complications to reduce (27.1%) and/or fixate (12.8%) the fracture. There were also a few early complications such as soft tissue-related problems in the area around the fracture and some late complications such as a high incidence of joint stiffness (51.4%) and malunions (24.3%).
Conclusions. Tibial pilon fractures are often associated to a high complications rate that makes it very difficult to anticipate long-term results. There is a direct relationship between the presence of radiographic signs of arthritis and poor long-term results. An excellent joint reduction does not guarantee the attainment of excellent long-term results; but it does lead to a higher probability of success.

Key words: *tibial fractures, tibial pilon, osteosynthesis.*

Fracturas del pilón tibial. Resultados funcionales a largo plazo

Objetivo. Estudio epidemiológico y funcional a largo plazo de las fracturas de pilón tibial ingresadas en nuestro servicio a lo largo de cinco años cuyo objetivo es determinar cuál fue la evolución a largo plazo de las mismas, analizar la posible influencia de la calidad de la reducción obtenida y del estado de las partes blandas en los resultados clínicos, y evaluar la relación existente entre el tipo de fractura, los signos degenerativos radiográficos y los resultados obtenidos.
Material y método. Se revisan 91 fracturas de pilón tibial en 87 pacientes (4 bilaterales), de las que 29 fueron mujeres (31,9%) y 62 varones (68,1%). Se realiza un estudio retrospectivo de todas las historias clínicas, citando posteriormente a los pacientes para la encuesta de funcionalidad según la escala de Duquennoy para el tobillo, la valoración objetiva de parámetros y la actualización de las radiografías.
Resultados. Los factores más afectados por la fractura, en la escala de valoración de Duquennoy, fueron la capacidad de carrera/salto con una media de 1,6/5 y la deambulación sobre terrenos irregulares (2,6/5); los que menos se vieron influidos por la lesión fueron la necesidad de utilizar bastones (4,3/5) y el perímetro de marcha (8,4/10). Destaca un elevado número de complicaciones iniciales para reducir (27,1%) y/o fijar (12,8%) la fractura; complicaciones precoces como problemas en las partes blandas perifracturias, y destacando entre las tardías la gran incidencia de la rigidez articular (51,4%) y las consolidaciones viciosas (24,3%).
Conclusiones. Las fracturas de pilón tibial habitualmente se asocian a una alta tasa de complicaciones que hace muy difícil la predicción de los resultados a largo plazo. Existe una

Corresponding author:
Ó. Fernández Hernández.
Servicio de Cirugía Ortopédica y Traumatología.
Hospital de León.
C/ Altos de Nava s/n.
24071 León.
E-mail: oscarfdezhdez@yahoo.es

Received: July 2006.
Accepted: May 2007.

relación directa entre la existencia de signos radiográficos de artrosis y los malos resultados obtenidos con el paso del tiempo. Una excelente reducción articular no asegura unos excelentes resultados a largo plazo, pero sí una mayor probabilidad de que éstos estén presentes.

Palabras clave: *fracturas de tibia, pilón tibial, osteosíntesis.*

Tibial pilon fractures affect the supramalleolar portion of the tibia and often extend to the distal articulating surface of the shinbone[1-4]. They may be caused by high-energy trauma, with high levels of comminution, or by rotational or shear movements arising from forceful dorsiflexion. Trauma in these cases is often of lower energy[3-11]. These fractures account for about 1% of lower limb fractures and less than 10% of all tibial fractures[4,7-10,12-14].

Multiple classifications have been proposed in the literature, of which the two most common are the ones by Rüedi-Allgöwer[15] and by AO/OTA[2] respectively. Rüedi and Allgöwer classify them into: I) fractures without displacement of the joint surface; II) displacement of the joint surface without comminution; III) displacement and comminution of the fragments. The AO classification is more comprehensive, Albert more complex: A) extraarticular fractures; B) partially articular fractures; C) fully articular fractures. The Ovadia and Beals classification[13] incorporates the virtues of the two: Simplicity and exhaustiveness: I) undisplaced fractures; II) minimally displaced fractures; III) displaced fractures with large fragments; IV) articular displacement with multiple fragments and metaphyseal defects; V) articular displacement with severe comminution. Kellam and Waddell[16] use a different classification that takes into account the mechanism of injury: A) rotational pattern with minimal or no comminution of the anterior cortex of the tibia, with two or more large tibial articular fragments, and often a short transverse or oblique fibular fracture; B) axial compression pattern with marked comminution of the anterior tibial cortex, with multiple tibial fragments, upward talar migration and narrowing of the joint.

For diagnosis, accurate x-ray views are fundamental; often A/P and lateral views are sufficient. Computed axial tomography (CAT) can be of enormous use in the surgical planning of complex fractures. Martin et al[17] show that CAT scans improve interobserver agreement as to how much of the joint surface is compromised by the fracture; but intraobserver reproducibility is not high enough to classify the fracture accurately. Nuclear magnetic resonance (NMR) is rarely necessary.

An added problem when it comes to treating tibial pilon fractures is the condition of the soft tissues. Patients have normally had a vehicle accident or sustained a fall, with high-energy trauma, and present with great comminution of the fragments and patent injury to the soft tissues, often covered in edema, which compromises the good results that open surgery has tended to show[4,12,14,18,19]. In the face of this problem, the use of external fixators[8,20,21], deferral of surgery[7] until the condition of the soft tissues has improved, or two-stage protocols[5,10,22] have been much used therapeutic options.

The purpose of this study was to determine what was the long-term evolution of tibial pilon fractures, analyze the potential influence of the quality of the reduction obtained and of the condition of the soft tissues on the clinical results achieved, and assess the relationship between type of fracture, x-ray degenerative signs and the results obtained.

MATERIALS AND METHODS

We performed a retrospective study of all tibial pilon fractures treated in our department between January 1997 and December 2001. We had two goals in mind: firstly, to perform an epidemiological study and, secondly, to analyze the functional results obtained. We analyzed the patients' personal data, the mechanism of injury, days of hospitalization, any events in the patients' previous history that could influence the final functional results, existence of associated injuries, classification of the fractures, complications, treatment and results. Eighty-seven patients were included in the study, with a total of 91 fractures (4 bilateral), of whom 29 were women (31.9%) and 62 men (68.1%). Mean age was 50.4 years (range 19-85). Fractures affected the right tibial pilon in 47 patients (51.6%) and the left pilon in 44 (48.4%). The chief mechanisms of injury were vehicle accidents (n = 36; 39.6%) and falls from a height (n = 24; 26.3%), followed by fortuitous falls, sprains, etc (n = 21; 23.1%), other high-energy accidents (n = 7; 7.7%) and sports accidents (n = 3; 3.3%). Mean length of primary hospital stay was 15.66 days (range 1-94).

According to Rüedi-Allgöwer's classification[15] there were 73 fractures that only affected the joint: 20 type I fractures (27.4%), 21 type II fractures (28,7%) y 32 type III fractures (43.5%); and there was another 18 fractures that were solely extraarticular, i.e. they could not be included as tibial pilon fractures according to this classification. Using the AO/OTA[2] classification, we obtained a total of 18 type A fractures (19.8%), 31 type B (34.1%) and 42 type C (46.2%). 26.4% (n = 24) of fractures were open and, according to the classification by Gustilo and Anderson, 9 were type I (9.9%), 9 type II (9.9%), 5 type IIIA (5.5%) and 1 type IIIB (1.1%). For closed fractures we used the classification by Tscherne: 26 grade 0 (28.6%), 26 grade 1 (28.6%), 14 grade 2 (15.4%) and 1 grade 3 (1.1%).

We also studied associated injuries: 7 instances of head and neck trauma (8.8%), 1 abdominal injury (1.1%), 10 thoracic lesions (11%), 4 vertebral fractures (4.4%) and 68 nonvertebral fractures (74.7%), including 45 fractures of the ipsilateral fibula (47.4%) and other lesions (n = 22; 24.2%).

In cases in which surgery was needed, procedures were performed a mean of 4.4 days (range 0-30) from admission; 0 days in all cases of emergency surgery (28 patients; 30.8%), and 30 days in the case of a patient admitted to the Intensive Care Unit (ICU) where surgery could not be performed earlier since his hemodynamic instability would have rendered the procedure life-threatening. Apart from this patient, the maximum number of days elapsed between admission and surgery was 16.

Treatment administered was as follows: 24 patients received orthopedic treatment (one of these was discharged against medical advice), 19 permanent external fixators, 1 temporary external fixator, 20 percutaneous osteosyntheses and 34 open osteosyntheses and internal fixation procedures. In 7 cases temporary bone traction was administered. In 4 cases it was necessary to introduce a transsyndesmotic screw to guarantee the congruency of the tibio-talo-fibular mortise; this screw was withdrawn once partial weight-bearing was authorized. No initial arthrodesis was performed. 20 patients had to be subjected to surgery after having received initial treatment (orthopedic in 4 cases). Most cases only required one reoperation (11 patients), 4 required a second one and one patient even a third one. We have excluded from this statistics surgeries carried out to extract the fixation materials. Different procedures were performed as a second surgical stage: 6 open osteosyntheses, 4 arthrodeses, 5 corrective osteotomies, 11 surgical cleaning procedures (8 open and 3 arthroscopic). No ankle prosthesis was implanted. Follow-up ranged between 2 months to 41 (mean: 16.3 months).

At a later stage and with a minimum follow-up of 37 months, patients were asked to come to the hospital for a personal interview. A functional assessment was made of their ankle, according to the Duquennoy scale[23] which evaluates both objective and subjective parameters; an updated ankle radiograph was also made. 21 fractures (19 patients) were excluded from the study for different causes: 6 had died at the time of follow-up, 6 could not be evaluated (4 had been operated on in other hospitals, 2 had paraplegia at the time of sustaining the injury), 5 were lost to follow-up and 2 did not come to their appointment, which gave us a total of 70 fractures making up the functionality study.

Once gathered, the data was analyzed on a personal computer and two kinds of statistical analysis software: SPSS v.12 (SPSS Inc. Chicago, Illinois) and Sigma v.1 (Horus Hardware S.A, Madrid).

RESULTS

57 excellent and good results were obtained, which were distributed across the following fracture types (Rüedi-Allgöwer classification [table 1]): 12 type I (92.3%), 13 type II (68.4%) and 14 type III (56%), with statistically significant differences (chi-square, $p < 0.05$). According to the AO/OTA classification, excellent and good results fell into the following types (n = 70): 10 type A (76.9%), 18 type B (78.3%) and 21 type C (61.8%). Fractures affected the following factors most severely, on Duquennoy's scale[23]: sprinting/ dumping capabilities (mean 1.6/5) and walking on uneven ground (2.6/5); those least affected by the injury were the need to use a walking stick (4.3/5) and the walking perimeter (8,4/10).

As regards the quality of fracture reduction, 26 (37.1%) were anatomical, 25 (35.7%) were acceptable reductions (interfragmentary space < 2 mm) and 19 (27.1%) poor (interfragmentary space > 2 mm).

Complications are listed in table 2, with a distinction being made between intraoperative (affecting the reduction and/or fixation of the fracture), early and late; within intraoperative complications a distinction is made between anatomical, acceptable and poor reduction. We have considered fixation to be poor in cases in which the desired fixation could not be obtained because of intraoperative problems, or where the fixation obtained was incorrect or insufficient. Results include 12.8% of poor fixations, 37,1% of anatomical reductions (n = 26), 35.7% of acceptable reductions (n = 25) and 27.1% of poor reductions (n = 19).

Within early complications (47.1%) there are wound dehiscences (12.8%), phlyctena (41,4%), superficial necrosis (20%), deep necrosis (5.7%), superficial infections (7.1%), deep infections (4,3%), infections of the pin-tract in external fixators (in 35% of fixators placed, although most

Table 1. Results obtained with the Duquennoy scale

AO/OTA		Assessment according to the Duquennoy scale							
		Poor		Fair		Good		Excellent	
	A1		0		0		1		2
A	A2	2	1	1	0	4	0	6	1
	A3		1		1		3		3
	B1		0		1		1		5
B	B2	1	1	4	2	5	3	13	6
	B3		0		1		1		2
	C1		2		1		2		2
C	C2	5	1	8	3	14	6	7	2
	C3		2		4		6		3

Rüedi-Allgöwer	Assessment according to the Duquennoy scale			
	Poor	Fair	Good	Excellent
I	0	1	2	10
II	2	4	6	7
III	4	7	11	3

Source: Duquennoy et al[23].

infections were superficial and resolved with empirical antibiotic treatment; however, on two occasions the infected pin had to be withdrawn), unsatisfactory reduction (14.3%; these were resolved through surgery [primary surgery in cases treated orthopedically] or wedges in the plaster cast) and thromboembolic disease (2.9%; two cases of deep venous thrombosis is spite of correct antithromboembolic prophylaxis).

Among late complications (64.3%) there is a predominance of joint stiffness (51.4%), delayed healing (11.4%), pseudoarthrosis (10%) and malunion (24.3%).

We later analyzed the existence of x-ray signs indicating arthritic degeneration (joint impingement, subchondral sclerosis, cysts, osteophytes, etc.) vis-à-vis functional results. In 26 cases there were no signs of arthritis, with 96.1% good or excellent results. In 44 cases there was some x-ray sign of arthritis, with 54.5% good or excellent results ($p < 0.05$).

When we analyzed the results obtained as a function of the degree of reduction achieved at the level of the joint surface, data show that 87.5% of patients where anatomical reduction was achieved presented with good/excellent results (fig. 1). This percentage decreased to 69.6% when reduction was acceptable and to 52.2% when it was poor ($p < 0.05$).

When a relationship was established between the degree of reduction obtained and the potential development of degenerative signs, we saw that 16.6% of anatomical reductions developed arthritic signs. This percentage increased to 82.6% when reduction was acceptable and to 91.3% when it was considered poor ($p < 0.01$).

No statistically significant relation was found between open fractures and long-term functional results. However, the results revealed a reverse relationship between the severity of soft tissue injury and the function level of the patient on the Duquennoy scale[23]. That relationship was almost of statistical significance ($p < 0.1$).

Tabla 2. Complications of tibial pilon fractures

	Complications	Number	%
Initial	Inadecuate fixation	9	12.8
	Poor fixation	2	2.9
	Articular penetration	19	27.1
Early	Wound dehiscence	9	12.8
	Phlyctena	29	41.4
	Superficial necrosis	14	20
	Deep necrosis	4	5.7
	Superficial infection	5	7.1
	Deep infection	3	4.3
	Pin/needle infection	7	35
	Loss of reduction	10	14.3
	Osteomyelitis	3	4.3
	Sudeck's disease	10	14.3
	Thromboembolism	2	2.9
Late	Stiffness	36	51.4
	Pseudoarthrosis	7	10
	Delayed healing	8	11.4
	Malunion	17	24,3

DISCUSSION

Tibial pilon fractures constitute a challenge for the orthopedic surgeon. They are often associated with a high rate of complications, which make it difficult to foresee their final outcome. In the last few years. There has been a change in the way these fractures are treated, with special attention being paid to the sparing of the soft tissues[1].

The most Commonly used classifications are those by Rüedi and Allgöwer[15] and the AO[2]. The classification by Rüedi and Allgöwer has the advantage of being terribly simple, but in our view has the drawback of not including solely metaphyseal fractures, which do not involve the joint. Many of these metaphyseal fractures, caused by axial compression mechanisms, present with severe comminution that greatly complicates reduction and osteosynthesis. The AO classification, though very comprehensive, is highly complicated and is associated to significant interobserver variability, partly due to the fact that fractures occur across a wide spectrum of severity[17]. Many of the problems associated with fracture classification result from the fact that the degree of severity is a continuum whereas classifications are categórical[25].

There are other less-used classifications, such as that by Ovadia and Beals[13], which is both simple and comprehensive. A good classification must be valid, reproducible and must give the fracture a prognostic value[6].

These types of fractures generally occur as a result of high-energy trauma, often vehicle accidents or falls from a height. However, in the last few years there has been considerable aging of the population, which has led to a significant increase in osteoporotic fractures[3]. In our series, there is a 23.1% incidence of fractures resulting from fortuitous falls or sprains. In the series by Pierannunzzi et al[3] this incidence is of 33%.

There is often an associated ipsilateral fibular fracture. Barei et al[27] defended, in general terms, the association of a fibular fracture with a greater severity of the tibial pilon fracture, with a predominance of AO type C fractures. An intact fibula is more commonly associated with tibial pilon type B fractures.

In line with the reviewed literature, we have found that this type of injury is more common in males (range 50-97, 4%)[3,7-9,19,27-29]. In line with other series, there is a clear predominance of severe fractures, Rüedi and Allgöwer type III (43.5%) and AO type C (46.2%) (range 23.8%-73.3%)[3,7,8,19,28], which will lead to a high rate of complications. 26% of fractures were open, similar to what has been reported by other authors (range 18.2-43.3%)[3,7-9,19,28-30].

Figure 1. ***(A)*** *Initial x-rays.* ***(B)*** *Post-op x-rays in a patients where open osteosynthesis was carried out, with good articular reduction.* ***(C)*** *Follow-up at 6 years with an excellent functional result (95/100).*

Many tibial pilon fractures occur in multi-trauma patients, who also have diverse other associated injuries. In most cases, the trauma causes other fractures, which could complicate the patient's natural evolution if they interfere with walking or with the use of walking sticks. In other cases, these associated injuries are much more severe, involving viscerae or other vital organs, and can determine in themselves the treatment to be administered. An external fixator placed in the emergency setting could be a viable solution in these cases since it affords the fracture the stability required for the care and hygiene of critical patients.

What is the ideal treatment of tibial pilon fractures? This is a question that still generates great controversy. The literature is full of reports praising or disparaging different surgical techniques. Kim et al[28] advocate reducing damage to the soft tissues by using external fixators and using arthroscopy for fragment reduction. McDonald et al[8] support the use of an Ilizarov-type external fixator since it enables early mobility when all pins proximal to the Joint are placed, thus affording less rigidity and faster healing. However, other authors[7,12] point out that the best results are to be achieved with open reduction and internal fixation (ORIF). Blauth et al[22] recommend a two-stage minimally invasive treatment (the first stage with open reduction and the use of an external fixator, with ORIF in the fibula and screws and/or Kirschner-wires through mini-incisions in the tibia, and a second stage using a buttress plate by means of a minimally invasive technique) for complex AO type C fractures, advising against an initial arthrodesis since articular damage or malalignment are not reliable indicators of joint degeneration. Borrelli et al[5,6] also prefer a two-stage approach, first with ORIF in the fibula and an external fixator to maintain the length and alignment of the tibia when the soft tissues have recovered. Hutson[20] advises against the use of autologous bone in the acute phase because it Could compromise even further the proper evolution of the soft tissues. At the beginning of the 60s, the AO developed treatment guidelines for ORIF: reconstructing the length of the fibula, reconstructing the joint surface, treating metaphyseal defects with bone graft if necessary and, lastly, using a buttress plate to keep the alignment[2,5,6,30]. In general, we prefer an emergency procedure —if at all possible— using mini-incisions if an adequate reduction of fragments can be achieved. If an emergency procedure is not feasible, it is advisable to wait 10-12 days until the condition of the tissues has improved. It is preferable to carry out a wider approach than use incisions that require the use of retractors, which might cause damage to the tissues. We insist on the need to spare the soft tissues as much as possible in order to avoid complications that could compromise the results of the surgical procedure.

The factors most severely affected by the fracture were the patients' capabilities for sprinting/dumping and for walking on uneven ground. Those least affected were the need to use walking sticks and the walking perimeter. Hutson[20] points out that the greatest difference with the control Group was found in the physical function parameter (SF-36).

It is impossible to predict the number of complications associated to complex tibial pilon fractures. In our case, these fractures were characterized by: a) long hospital stays, partly due to the injuries associated to the fracture; b) a large number of reinterventions, and c) a large amount of initial, early and late complications.

We should stress the difficulties inherent in reducing and fixating comminute fractures as well as the various (generally favorably resolved) complications affecting the soft tissues and the late joint mobility problems that tend to arise, which require rehabilitation to restore an adequate ROM. Blauth et al[22] report 94% post-traumatic arthritis, 10% osteomyelitis and 23% secondary arthrodeses. Pierannunzii et al[3] report 18% deep infections, 9% malunions and 5% pseudoarthrosis. Sirkin et al[10] claim that soft tissue-related complications can be reduced in two ways: with external fixators associated to limited incisions, or with two-stage reconstructions. We advocate the use of extreme care when manipulating soft tissues intraoperatively and when determining the exact time of surgery, which should be performed as an emergency whenever possible, or be deferred until the 10th-12th day, by which time soft tissues will have healed somewhat.

Postoperative care of soft-tissues is also indispensable, since a complication on that front could thwart all the work done in the operating theater.

Bhattacharyya et al[29] show that the posterolateral approach does not decrease the rate of wound-related complications, in spite of a better soft tissue coverage, and only recommend it in fractures where comminution or the articular step-off is chiefly posterior. The greatest problem of external fixators is normally pin tract infection[21], which we have generally treated by means of oral antibiotics without the need for admission.

In refractory cases we have either withdrawn the infected pin, if the time of evolution allowed it, or treated the patient with a rifampicin injection at the infection site, with excellent results.

The two factors most directly related to soft tissue problems are open fractures and comminution[9]. On initial assessment, special attention must be paid to fragment displacement, since posterior displacement of the distal fragment could cause the anterior tibial fragment to bring pressure to bear on the soft tissues from the inside, turning a closed into an open fracture because of tissue necrosis. Early fracture reduction is a simple maneuver that can mitigate imminent complications. As regards complications associated to the use of an external fixator, Pollak et al[31] report greater stiffness levels as compared with ORIF. Pugh et al[30] report equal levels of efficiency in treatments with ORIF, unilateral or circular external fixator, although they signal a higher healing rate for external fixators.

An analysis of the results obtained reveals a direct statistically significant relation between fracture type (according to Rüedi and Allgöwer's classification[15] and the final functional assessment, which implies that the worse the fracture type the worse the long-term results. However, this relationship could not be demonstrated using the AO classification. This could be due to the great complexity of this classification, which could easily make the observer include a certain fracture under the wrong heading. It is extremely complex to compare the results of the different published series because of the great variability of assessment scales used, the variations in the percentages of existing complex fractures, and the huge array of associated injuries that exert a direct influence of the patients' evolution. Nonetheless, the literature seems to bear out this directly proportional relation between severity of damage and the patients' evolution[3,21]. In spite of this, Hernández-Hermoso et al[19], did not find a statistically significant relation. Williams et al[32] determined that severity of damage is highly correlated with osteoarthritis, but not with the clinical results obtained. In fact, paradoxically, the better the articular reduction obtained, the worse the SF-36 questionnaire results.

Some authors[32] point out the relationship that exists between the patients' cultural level and their good evolution, as well as the role played by the prospect of an economic compensation in hindering uneventful resolution. Likewise, they play down the importance of the severity of damage

Figure 2. *(A) Initial x-rays. (B) X-rays following orthopedic reduction. (C) Long-term evolution with a poor final result. Note the articular step-off > 2 mm and valgus of 10°, which led to a significant final articular impingement.*

and the quality of reduction. Pollak et al[31] report poorer results in married patients, which differs from the literature in general, in patients with low cultural levels and in those on low incomes.

Several authors[1,2,19,21] argue that x-ray Imaging does not necessarily reflect clinical and functional results. Our series shows, however, a direct statistically significant relation between the existence of x-ray arthritic signs and poor long-term results (fig. 2). It is important to stress the existence of a clear relationship between articular reduction and long-term functional results[5,7,20]. It is of vital importance to obtain good articular congruence. Incongruences greater than 1-2 mm are considered a therapeutic failure and inevitably develop into post-traumatic arthritis[3] (fig. 3). Nevertheless, obtaining a successful reduction is not enough to avoid articular degeneration; it is also necessary for the reduction to be anatomical. Although an excellent articular reduction does not guarantee good results, it increases the likelihood that these may be obtained.

Nonetheless, an anatomical reduction does not prevent the development of post-traumatic arthritis in every single case[5], since a certain percentage of anatomical reductions is bound to evolve unfavorably. How can this be explained? The severity of damage on the Joint surface plays a very significant role in determining the risk of developing post-traumatic arthritis[25]. Aggression to the articular cartilage is probably closely related to this fact.

Figure 3. *(A) Initial x-rays. (B) X-rays with transskeletal traction. The patient was immobilized with a short-leg cast without duly correcting the articular step-off. (C) Evolution towards early arthritis that requires an ankle arthrodesis.*

REFERENCES

1. Marsh JL, Saltzman CL. Fracturas de tobillo. En: Bucholz RW, Heckman JD, editores. Rockwood y Green's: Fracturas en el adulto. Tomo 3. Madrid: Marbán SL; 2003. p. 2001-90.
2. Sommer C, Rüedi T. Tibia: distal (pilón). En: Rüedi TP, Murphy WM, editores. Principios AO del tratamiento de las fracturas. Barcelona: Masson; 2003. p. 543-60.
3. Pierannunzii L, De Bellis U, D'Imporzano M. Il trattamento chirurgico delle fracture del pilone tibiale. Ital J Orthop Traumatol. 2002;25:11-23.
4. López-Prats F, Sirera J, Suso S. Fracturas del pilón tibial. Rev Ortop Traumatol. 2004;48:470-83.
5. Borrelli J Jr, Catalano L. Open reduction and internal fixation of pilon fractures. J Orthop Trauma. 1999;13:573-82.
6. Borrelli J Jr, Ellis E. Pilon fractures: assessment and treatment. Orthop Clin North Am. 2002;33:231-45.
7. Ladero-Morales F, Sánchez-Lorent T, López Oliva-Muñoz F. Resultados del tratamiento quirúrgico de las fracturas complejas del pilón tibial. Rev Ortop Traumatol. 2003;47:188-92.
8. McDonald MG, Burgess RC, Bolano LE, Nicholls PJ. Ilizarov treatment of pilon fractures. Clin Orthop. 1996;(325): 232-8.
9. Sands A, Grujic L, Byck DC, Agel J, Benirschke S, Swiontkowski MF. Clinical and functional outcomes of internal fixation of displaced pilon fractures. Clin Orthop. 1998;(347): 131-7.
10. Sirkin M, Sanders R. The treatment of pilon fractures. Orthop Clin North Am. 2001;32:91-102.
11. Topliss CJ, Jackson M, Atkins RM. Anatomy of pilon fractures of the distal tibia. J Bone Joint Surg Br. 2005;87B:692-7.
12. Bone LB. Fractures of the tibial plafond. The pilon fracture. Orthop Clin North Am. 1987;18:95-104.
13. Ovadia DN, Beals RK. Fractures of the tibial plafond. J Bone Joint Surg Am. 1986; 68A:543-51.

14. Lin MS, Lee HM, Hou YT, Shih JT, Tan CM. Treatment of tibial pilon fractures using the Link May Anatomic Bone Plate. J Chin Med Assoc. 2003;66:423-8.
15. Rüedi TP, Allgöwer M. The operative treatment of intra-articular fractures of the lower end of the tibia. Clin Orthop. 1979;(138):105-10.
16. Kellam JF, Waddell JP. Fractures of the distal metaphysis with intra-articular extension: the distal tibial explosion fracture. J Trauma. 1979;19:593-601.
17. Martin JS, Marsh JL, Bonar SK, DeCoster TA, Found EM, Brandser EA. Assessment of the AO/ASIF fracture classification for the distal tibia. J Orthop Trauma. 1997;11:477-83.
18. Hahn DM. Current principles of treatment in the clinical practice of articular fractures. Clin Orthop. 2004;(423):27-32.
19. Hernández-Hermoso JA, Fernández-Sabaté A, Rodríguez-Pérez D, Garreta-Anglada JL, Morales de Cano JJ. Fracturas del pilón tibial: influencia del tipo de fractura y de la exactitud de la reducción articular en el pronóstico. Rev Ortop Traumatol. 2001;5:389-97.
20. Hutson JJ. The treatment of distal tibia periarticular fractures with ilizarov fixators. Tech Orthop. 2002;17:71-92.
21. Watson JT, Moed BR, Karges DE, Cramer KE. Pilon fractures: treatment protocol based on severity of soft tissue injury. Clin Orthop. 2000;(375):78-90.
22. Blauth M, Bastian L, Krettek C, Knop C, Evans S. Surgical options for the treatment of severe tibial pilon fractures: a study of three techniques. J Orthop Trauma. 2001;15:153-60.
23. Duquennoy A, Mestdagh H, Tillie B, Stahl Ph. Résultats fonctionnels de l'arthrodèse tibio-tarsienne. Rev Chir Orthop. 1985;71:251-61.
24. Espinar E. Sistemas de valoración de los resultados clínicos en la cirugía del pie. En: Núñez-Samper M, Llanos LF, Viladot R, editores. Técnicas quirúrgicas en cirugía del pie. Barcelona: Masson; 2003. p. 361-70.
25. Beardsley C, Marsh JL, Brown T. Quantifying comminution as a measurement of severity of articular injury. Clin Orthop. 2004;(423):74-8.
26. Audige L, Bhandari M, Kellam J. How reliable are reliability studies of fracture classifications?: a systematic review of their methodologies. Acta Orthop Scand. 2004;75:184-94.
27. Barei DP, Nork SE, Bellabarba C, Sangeorzan BJ. Is the absence of an ipsilateral fibular fracture predictive of increased radiographic tibial pilon fracture severity? J Orthop Trauma. 2006; 20:6-10.
28. Kim HS, Jahng JS, Kim SS, Chun CH, Han HJ. Treatment of tibial pilon fractures using ring fixators and arthroscopy. Clin Orthop. 1997;(334):244-50.
29. Bhattacharyya T, Crichlow R, Gobezie R, Kim E, Vrahas MS. Complications associated with the posterolateral approach for pilon fractures. J Orthop Trauma. 2006;20:104-7.
30. Pugh KJ, Wolinsky PR, McAndrew MP, Johnson KD. Tibial pilon fractures: a comparison of treatment methods. J Trauma. 1999;47:937-41.
31. Pollak AN, McCarthy ML, Bess RS, Agel J, Swiontkowski MF. Outcomes after treatment of high-energy tibial plafond fractures. J Bone Joint Surg Am. 2003;85A:1893-900.
32. Williams TM, Nepola JV, DeCoster TA, Hurwitz SR, Dirschl DR, Marsh JL. Factors affecting outcome in tibial plafond fractures. Clin Orthop. 2004;(423):93-8.

Conflict of interests

The authors have declared to have no conflict of interests.