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Neurological complications of high tibial osteotomy—the fibular osteotomy as a causative factor: a clinical and anatomical study

J R Wootton FRCS*
Orthopaedic Senior Registrar

C A N MacLaren FRACS†
Orthopaedic Senior Registrar

Robert Jones and Agnes Hunt Hospital, Oswestry

M J Ashworth FRCS‡
Orthopaedic Registrar

Hartshill Orthopaedic Hospital, Stoke-on-Trent

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A clinical study of 105 upper tibial osteotomies was undertaken to investigate the incidence, pathology and outcome of perioperative neurological deficit. Motor weakness and/or sensory deficit occurred in 21 patients (20%) and in half of these the deficit was permanent. For descriptive purposes the fibula was divided into four zones. The occurrence of a neurological deficit was clearly related to the level of the fibular osteotomy.

An anatomical explanation is proposed for this complication, based on cadaveric studies. Due to unacceptably high levels of complications it is recommended that the fibular osteotomy should not be performed in zones II and III (from just below the fibular head to 15 cm distal to this level).

Weakness of toe or foot dorsiflexion, with or without a sensory deficit, is well-recognised as a complication of proximal tibial osteotomy (Coventry *(1)*, Devas *(2)*, Maquet *(3)*, Gibson *et al. (4)*), the reported incidence ranging from 2% to 20% (Maquet *(3)*, Jackson and Waugh *(5)*). This has been described as 'the most puzzling and potentially dangerous symptom after tibial osteotomy' (Jackson and Waugh *(6)*). Neurological complications of high tibial osteotomy are characterised by pain over the front of the foot and ankle, with weakness of extensor hallucis longus alone, or more extensive weakness also involving tibialis anterior and the muscles innervated by the common peroneal nerve. Weakness can also be associated with sensory loss.

Many aetiological factors have been proposed, such as tight plasters (Coventry *(1)*) and bandages (Devas *(2)*), traction on the nerve and vascular changes in the anterior compartment (Jackson and Waugh *(7)*). However, these have since been refuted (Jackson and Waugh *(7)*, Gibson *et al. (4)*). More recently, it has been proposed that the division of the fibula is the significant aetiological factor for the occurrence of neurological complications after high tibial osteotomy (Curley *et al. (8)*). This had previously been proposed in 1979 by Stürz and Rosemeyer *(9)*.

This present study was undertaken to document the incidence of complications and to identify any particular risk factors to account for their occurrence.

Patients and methods

In all, 105 limbs in 95 patients (63 men and 32 women, average age 58 years at operation) were studied retro-

Present appointments:
* Orthopaedic Consultant, Oswestry and Wrexham Maelor Hospitals
† Orthopaedic Consultant, York District Hospital
‡ Orthopaedic Registrar, The Nuffield Orthopaedic Centre, Oxford

Correspondence to: Mr M Ashworth FRCS, Roseneath, 145 Main Road, Long Hanborough, Nr Witney, Oxfordshire OX8 8JZ

spectively 2–6 years after upper tibial osteotomy and associated fibular osteotomy. The surgery was performed by five different surgeons (consultants or senior registrars).

A barrel vault osteotomy of the tibia was performed on 85 cases, the remaining 20 had a closing wedge osteotomy. Compression clamps were used to maintain the reduction in 70 cases; in the remaining 35 cases plaster-of-Paris was used. Other details studied included the tourniquet time, the degree of pre- and postoperative varus or valgus (to give the amount of correction) and the level and type of fibular osteotomy. For the purpose of this study the fibula was divided into four descriptive zones:

Level I Detachment of the tibiofibular syndesmosis or fibular head osteotomy.
Level II Fibular osteotomy between 0 and 7 cm below the fibular head.
Level III Fibular osteotomy between 8 cm and 15 cm below the head.
Level IV Fibular osteotomy 16 cm or more below the fibular head.

All patients with a recorded neurological complication attended a clinic for review. Any patient in whom there was any doubt or for whom the notes were inadequate also attended the review clinic. At clinical review the presence and type of any neurological complication was noted. Muscle power was assessed according to the MRC scale and sensation tested for light touch and pin prick.

Results

An average total correction of 19° was achieved from a mean preoperative tibiofemoral angle of 10° varus to a mean of 9° of anatomical valgus. The tourniquet time was only recorded in half of the cases, here it averaged 52 min (range 35–65 min).

The fibula was managed differently by each surgeon. The level and type of fibular osteotomy are shown in Table I.

Of the 105 osteotomies performed, 21 cases were complicated by a neurological deficit as documented in the postoperative notes.

Weakness

Postoperative muscle weakness (MRC 3 or less) developed in 19 limbs. The muscles affected were extensor hallucis longus alone or in combination with tibialis anterior. Weakness of the latter appeared to recover more rapidly than that of extensor hallucis longus alone; 11 patients had recovered fully by 24 months. The spectrum and nature of the transient deficits is shown in Table II. In all, 10 patients had permanent deficit at follow-up (Table III). Of these, seven involved extensor hallucis longus weakness without tibialis anterior weakness.

Table I. Level of fibular osteotomy

Zone	*Number (segment excised/oblique osteotomy)*	*Complications*
I	5 (2/3)	0
II	25 (15/10)	4
III	69 (41/28)	17
IV	6 (1/5)	0
Total	105 (59/46)	21 (20%)

Table II. Transient complications

Complication	*Number*	*Recovery time*
Numbness only	2	6 and 12 weeks
Tibialis anterior and EHL weakness, no numbness	1	12 weeks
Tibialis anterior and EHL weakness with numbness	4	7 to 24 months
EHL weakness alone	4	10 to 16 months
Total	11	

EHL, extensor hallucis longus

Sensory deficit

Only two patients developed sensory loss without motor deficit and they recovered at 6 and 12 weeks, respectively. However, 11 cases developed sensory loss in association with muscle weakness (Table II and Table III). Although seven were considered prolonged (lasting more than 2 years), in only one of these was the numbness permanent. The sensory losses were in the cutaneous distribution of the deep peroneal nerve or, less commonly, part of the superficial peroneal nerve distribution in the foot or ankle.

Fibular osteotomy

The level of the fibular osteotomy was the only variable which influenced the incidence of neurological complications (Table I). Most complications occurred in those patients who underwent fibular osteotomy in zone III, and together zones II and III contributed all of the complications. We could detect no significant difference between those patients with a transient or permanent deficit related to the zone of osteotomy.

Table III. Permanent complications

Complication	*Number*	*Time from surgery*
Tibialis anterior and EHL weakness	3	3 years
EHL weakness and transient numbness	6	2-6 years
EHL weakness and permanent numbness	1	4 years
Total	10	

EHL, extensor hallucis longus

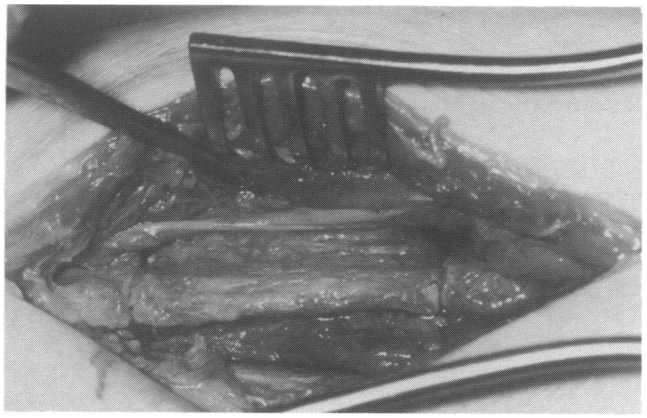

Figure 1. Superficial peroneal nerve adjacent to fibula.

These complications did give rise to genuine disabilities. Although in 11 of 21 patients the weakness of tibialis anterior and extensor hallucis longus was not permanent they were a significant disability while they lasted and were of concern to both patient and surgeon.

Of the 10 patients whose deficit was still present at follow-up, six had only minor disability (those with isolated extensor hallucis longus weakness and transient numbness). Of the other four, one patient was using an orthosis to help control the weakness of tibialis anterior and extensor hallucis longus, two others had been offered fusion of the great toes as a result of deficits which included extensor hallucis longus weakness and the fourth with extensor hallucis longus weakness and a sensory deficit had decided against any further treatment.

There was no correlation between the appearance of neurological complications and the angle of correction achieved at operation, the tourniquet time, type of fibular osteotomy, the type of fixation or postoperative immobilisation.

Anatomical studies

The anatomy of the fibula and its neurovascular relations were studied in a total of 12 cadaveric limbs.

The incision was centred at zone III as this was the most common site for fibular division in this study and was associated with the highest incidence of neurological complications.

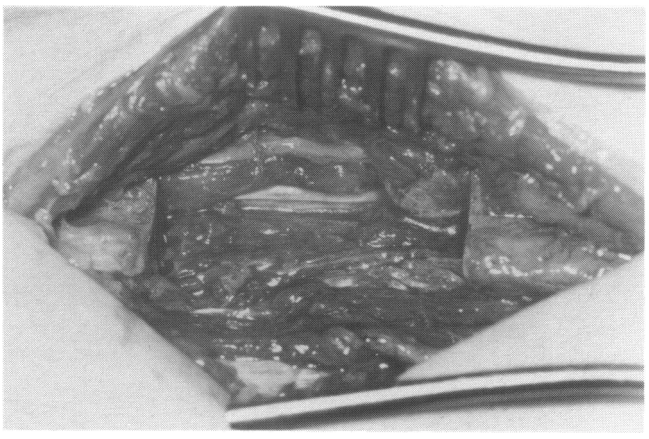

Figure 2. Fibula removed to show deep peroneal nerve.

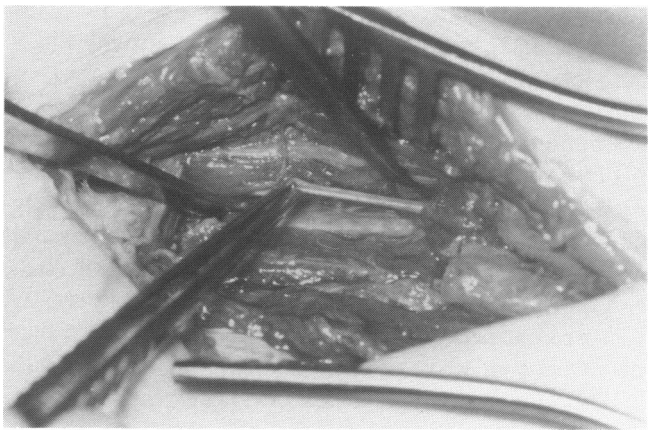

Figure 3. Branch to extensor hallucis longus.

The common peroneal nerve having spiralled around the neck of the fibula divides into the deep and superficial peroneal nerves within the peroneus longus. These two nerves stay closely related to the fibula for about 12 cm below the fibular head, gradually migrating away from the bone as they move more distally. Figures 1 and 2 show the deep peroneal nerve lying adjacent to the deep aspect of the fibula. The branch to the tibialis anterior is given off proximal to the branch to extensor hallucis longus. The branch to extensor hallucis longus is consistently given off at about 9 cm below the tibiofibular joint (Fig. 3) and it is at, and slightly distal to, this level that the nerve appears most at risk from the fibular osteotomy.

Discussion

Jackson and Waugh *(5)* showed that the incidence of weak dorsiflexion was much greater when the tibia was divided below the tubercle (25%) compared with supratubercle osteotomy (up to 12%), but no explanation was offered for this difference. Jokio *et al. (10)* reported a higher complication rate if the fibula is divided between 10 cm and 20 cm from the fibular head.

The tethering effect of the fibula during tibial osteotomy can be released in several ways; by detachment of the tibiofibular syndesmosis, detachment osteotomy of the fibular head or division of the shaft. In our series the most popular method was midshaft osteotomy (zone III) and it was noted that neurological complications were proportionally more common in patients who underwent osteotomy at this level.

Our study demonstrates the vulnerability of both the superficial and deep peroneal nerves and their branch to extensor hallucis longus when the fibula is divided in its mid-portion. The tibialis anterior would not be affected, as its branch is generally given off more proximally. Damage to the branches in this region would therefore affect extensor hallucis longus with or without sensory disturbance.

Isolated tibialis anterior weakness was not seen, but when tibialis anterior weakness was seen (eight cases out of a total of 21 complications) the association with other neurological deficits suggested that the neurological lesion could represent damage to the common peroneal nerve at or around the level of origin of the more proximal branch to tibialis anterior, perhaps while performing the tibial osteotomy. Whereas weakness of the more distally innervated extensor hallucis longus was seen on several occasions (13 out of 21) to be the only muscle affected, with or without sensory loss (Table II and Table III).

In a recent paper, Kirgis and Albrecht *(11)* noted that there were connective tissue fibres tethering the two main divisions of the common peroneal nerves and their branches to the periosteum of the tibia and fibula. Given our anatomical findings, intraoperative damage to these nerves or their branches either directly or via traction on the connective tissue fibres would explain the spectrum of deficit commonly found in association with the fibular osteotomy.

This study clearly relates the level of the fibular osteotomy to the risk of clinical complications. The cause of such complications is likely to be intraoperative damage to the branches of the common peroneal nerve during osteotomy of the fibula. The incidence is highest when the fibula is divided in zones II and III (from just below the fibular head to 15 cm below the fibular head). In this study there were no neurological complications associated with dividing the fibula in zones I and IV; however, the numbers were small.

Conclusions

Neurological deficit after high tibial osteotomy is not always transient or minor.

There appear to be two distinct groups of complications:

The first, perhaps related to the high tibial osteotomy, affects the tibialis anterior in association with other motor and sensory deficits.

The second group with more distal lesions related to the fibular osteotomy, spares the tibialis anterior but affects extensor hallucis longus either alone or in combination with sensory losses. This second group taking longer to recover than the first.

This is the first clinical study to clearly relate the level of the fibular osteotomy to the risk of clinical complications.

Recommendations

It is recommended that the fibular osteotomy should not be performed in zones II and III when it may more safely be performed in zones I and IV.

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