THE BALL AND SOCKET ANKLE JOINT

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This paper reports fifteen cases of ball and socket articulation at the ankle followed up for an average of twelve years. All patients showed inequality of leg length. Ten patients showed coalitions of the bones of the hindfoot and nine patients had a reduction in the number of bony elements of the forefoot. Other associated anomalies are described. The abnormality seems to be part of a congenital short-limb malformation, perhaps modified by adaptive change associated with rigidity of the hindfoot. Surgical intervention was not required in any patient in the series.

The ball and socket deformity of the ankle joint has received little attention in the English literature. It was first described by Lamb in 1958. On reviewing five cases he described an abnormal articulation in which the shape of the talus and the mortice of the tibia had been changed. The form of the trochlear surface of the talus is normally convex from before backwards and concave from side to side. In this condition the concavity is lost and the superior surface of the talus approaches the shape of a sphere. The mortice for the talus becomes moulded into a cup-like cavity and the articulation assumes the shape of a ball and socket joint (Fig. 1). Accompanying this abnormality of the joint are other changes, particularly coalition of the bones in the hindfoot and shortening in the involved limb.

Review of the German literature shows that this condition was described earlier by Politzer (1931), Korvin (1933), Kewesch (1934) and Wertheman (1952). More recent work by Imhäuser (1960, 1970), Henssge and Engelke (1970), Fischer and Refior (1972) and Köbel and Hermann (1975) has concentrated on the probable aetiology.

The purpose of this paper is to describe fifteen patients who have ball and socket articulations at the ankle, to give an account of the associated anomalies, to suggest the aetiology and to report on long-term follow-up.

MATERIAL

Fifteen cases were available for review. A clinical description together with radiographs were available showing the foot, the ankle and the axial skeleton at the time of diagnosis. Almost all the patients came from the South Wales area, their ages ranged from seven to sixteen years, and the time of follow-up varied from three to twenty-five years with an average of twelve years. Eight patients were male and seven female.

PRESENTATION AND FINDINGS

The initial presentation of these patients was because of associated abnormalities rather than because of symptoms related to the ankle. All patients presented with inequality of leg length, and the abnormal articulation was found in the short limb. Two patients presented with abnormalities of the foot: one had a high arched and short foot, and the other a club foot. One patient presented with scoliosis. Abnormalities of the forefoot were commonly found, nine patients showing absence of at least one toe (Fig. 2). Closer questioning of relatives showed that one child had been brought for advice because of the absence of two toes but this had not been
followed up at that time. Syndactyly of three toes was noticed on one occasion.

One patient had short stature and also complained of some restriction of movement of the ipsilateral arm. Examination revealed restricted pronation and supination although the radial head appeared to be normally located.

Radiological findings. The ball and socket ankle articulation was present in all cases. Radiographs were available showing the lower spine as were grid films of the lower limbs. A number of abnormalities were found at other sites.

Axial skeleton. Spina bifida occulta was present in three patients; there was no associated neurological abnormality. One other patient had an absent twelfth rib and transverse process on the side of shortening, and also sacralisation of the fifth lumbar vertebra.

Lower limb. In the lower limb all patients showed shortening on one side. In eight patients the shortening was essentially confined to the tibia; in two it was mainly femoral and in the remainder the discrepancy was divided between the two bones. The shortening averaged 5 centimetres. One patient showed failure of development of the upper femoral epiphysis on the affected side, and another had fibular hypoplasia.

Foot. In ten patients abnormalities of the hindfoot were identified and these were in the form of coalitions of the tarsal bones. The most common anomaly was fusion of the os calcis and talus which was seen on eight occasions. The navicular was also included in the coalition in four patients and in two of these it had a hypoplastic form (Figs. 3 and 4). The cuboid was involved on three occasions and was hypoplastic in two of these. The talus and navicular were seen to be fused in two cases without involvement of the os calcis. In patients with no radiological evidence of fusion, the subtalar joint appeared abnormal on two occasions with the talus appearing elongated and with diminution of the subtalar and talonavicular joint spaces (Fig. 5).

Abnormalities of the forefoot were also commonly found. In nine patients the fifth toe and metatarsal were absent and in two of them the fourth ray was also missing. Another patient had no fourth toe although the metatarsal was present. The lateral cuneiform was absent in three (Figs. 6 and 7) and fusion of the metatarsal bases was seen on one occasion.

RESULTS

Of the patients surveyed, only two had complaints relating to the ankle. One patient complained of a feeling of instability in the joint, particularly on uneven ground. The other suffered discomfort at the front of the ankle after an industrial injury, and had been treated by physiotherapy to which he had responded well and had resumed his normal occupation.

Clinical assessment of patients revealed a normal range of dorsiflexion and plantar flexion. The range of inversion and eversion was slightly greater than on the normal side. In the patients with no hindfoot coalition but with an abnormal radiological appearance of the subtalar joint, there was a reduction in the range of subtalar movement.
All patients were wearing normal shoes, often with a raise to compensate for the inequality of leg length. The patient who complained of instability had a high-sided shoe which relieved his symptoms.

Radiological assessment revealed surprisingly little evidence of degenerative change in the ankle. Some of the patients reviewed were in their fifth decade, yet showed no evidence of degenerative change.

**DISCUSSION**

Interest in the ball and socket ankle articulation has centred mainly on its aetiology and little mention has been made of the ultimate outlook for these patients. Discussion of the mechanism of its production has polarised into two avenues of thought. Lamb (1958) in his original article suggested that the abnormal articulation was part of a congenital short-limb syndrome, whereas Imhäuser (1960) and later Penrose (1974) have concentrated on the hindfoot abnormality and suggested that the ankle joint formation is the result of adaptive change brought about by loss of inversion and eversion at the subtalar joint. A review of the development of the lower limb lends support to the concept of a congenital malformation.

From the work of Gardner and O'Rahilly (1968) with staged embryos it would seem that the formation of the lower limb depends on the critical period from three to six weeks after fertilisation, that is from just before the limb buds appear until differentiation is well under way. Henssge and Engelke (1970) studied the shapes of the articular surfaces during the development of the foot and found that in the ankle there was a high degree of differentiation before a cavity was complete. The general conclusion was that elements of the foot have adult-like shapes and arrangements by the end of the first seven weeks and before cavitation occurs. Differentiation of the ankle occurs at an earlier stage than it does at the subtalar joint and the form of the ankle is well delineated before the formation of the subtalar cleft. In the foot itself, differentiation into adult-like elements occurs approximately between the fifth and seventh weeks of gestation (Gardner, Gray and O’Rahilly 1959). As all the elements of the foot have begun to chondrify by the seventh week their number and arrangement must be determined before this time. Comparative studies with animals suggest that the numbers are determined at four to five weeks, overgrowth occurring earlier than reduction.

The incidence of coalitions in the foetus and embryo is surprisingly high. In a small number of
embryos talocalcaneal and calcaneocuboid fusions were seen. In the foetus abnormalities were more common, talocalcaneal and calcaneonavicular fusions being seen as well as those between the lateral cuneiform and the third metatarsal. Fusions were not always complete and in some cases were tenuous. Since the incidence was higher than in the adult, it has been assumed that some break down on weight-bearing.

From this work it would seem that all these abnormalities may develop at a very early stage of intra-uterine life. The reduction of elements in the forefoot may be determined by five weeks after ovulation, the shape of the ankle by seven weeks. The subtalar cleft forms at a later stage. The reduced development of one lower limb must be determined by the end of six weeks. Coalitions are seen at an early stage. The occurrence of the ball and socket articulation may be involved in this overall development abnormality.

Leonard (1974) and Wray and Herndon (1963) studied the coalition of hindfoot bones occurring without abnormalities of the ankle joint itself. Leonard found a familial trait and felt that hindfoot coalitions were inherited as a unifactorial disorder with incomplete penetrance, this inherited characteristic supporting the concept of foetal maldevelopment. Our study has not revealed a familial characteristic.

Imhäuser (1960) suggested that remodelling of the ankle joint occurred as a result of loss of mobility of the hindfoot and his patients all showed talocalcaneal fusions. Fischer and Refior (1972), in a review of the literature, showed a high incidence of hindfoot coalition, which was present in twenty-five of twenty-nine collected cases. Similarly Penrose (1974) in his series found an incidence of hindfoot coalition of 75 per cent. It is suggested that when normal weight-bearing starts, the ankle joint adapts to the relative loss of subtalar movement caused by the hindfoot coalition and adopts the ball and socket shape. Imhäuser suggested that this formation took place between two and four years of age. Fischer and Refior described a case in which adaptation had taken place after a Grice Green arthrodesis at the age of six. Ten of our patients exhibited coalitions in the hindfoot although talonavicular fusions accounted for two of these. Abnormality of the subtalar joint without fusion was seen on two occasions. It would seem reasonable to assume that loss of inversion and eversion at the normal level would account for the alteration in shape of the ankle, but there was no convincing evidence that the shape had been normal before regular weight-bearing.

Penrose suggested that close grouping of tarsal bone nuclei might herald subsequent coalition and he also noted a hypoplastic lower tibial epiphysis at an early stage. Early radiographs were available for one of our patients but there was no indication of this. Leonard in his series of cases of tarsal coalition, saw no ball and socket ankle joints. One might also expect to find a ball and socket articulation in patients who have had an arthrodesis for the treatment of club feet. However, no such cases have been reported. Only with the use of an arthrogram would the actual shape of the cartilage model of the ankle joint be clearly defined. It is conceivable that the form of articulation is developed before weight-bearing so that hindfoot immobility may be a secondary development.

Henssge and Engelke (1970) saw the formation of a ball and socket ankle joint as part of a malformation syndrome particularly related to defects in the developing fibula. In their series, fibular defects were always present. Other series show this abnormality to be relatively infrequent. A hypoplastic fibula was only seen once in this series. Its infrequency would suggest that it may be a related abnormality rather than part of the causative mechanism.

All the patients we have studied have exhibited a short leg on the same side as their abnormal ankle. A large number have had other developmental defects, particularly reduction malformations of the foot. Both of these features suggest a congenital abnormality acting in the formation of the limbs. We have seen other abnormalities of the axial skeleton in a small number of cases. Hindfoot coalition has not always been present and it may have a separate aetiology. It provides a mechanism whereby the shape of the ankle may be altered as an adaptation to loss of inversion and eversion, and may thus allow for the complete development of an already predetermined abnormality.

The most interesting finding has been the lack of symptoms resulting from this malformation. Only two patients had complaints related to their ankles and these were managed satisfactorily by simple means. Normal shoes were worn with one exception and no bracing was required at any stage. In none of this series was operative intervention required to control problems of instability. The development of arthritic changes which one would expect at an early stage does not seem to take place. One patient had complaints suggestive of early degenerative change, but radiologically the joint surfaces appeared intact. Should patients require operation in the future then fusion of the ankle joint would seem to be the treatment of choice.

REFERENCES


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