Ann R Coll Surg Engl 1997; 79: 441–446

Improving the outcome of paediatric orthopaedic trauma: an audit of inpatient management in Southampton

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Key words: Audit; Trauma; Child; Fracture fixation

The patterns, management and outcome of non-fatal orthopaedic injury in childhood was audited over a 1 year period in Southampton.

A computer-based audit (1 September 1993 to 31 August 1994) was conducted of all children aged under 15 years who were admitted to the orthopaedic unit after accidental injury. Management was audited by studying the primary conservative and operative treatment methods employed. Treatment outcome was evaluated in terms of need for secondary operative treatment, salvage internal fixation, length of hospital stay and unplanned readmission.

In all, 398 children, representing 50/10 000 of the local paediatric population, were admitted with a traumatic injury. There was a significant ($P < 0.001$, Kolmogorov–Smirnov) seasonal variation in admission rate. There were 87.3% admissions required for fractures, 8.5% after soft tissue injury and 2.2% after joint injury.

The following areas were identified where management and outcome could be improved:

1. **A 12.1% readmission rate (47/346) in children with fractures owing to a 16% incidence of loss of position after closed reduction of distal radial, forearm shaft and distal humeral fractures.**
2. **In all, 24% of internal fixation procedures were performed as 'salvage' after failure of conservative treatment, entailing either reoperation during the initial admission or a further unplanned readmission.**
3. **A prolonged inpatient stay for patients with femoral fractures owing to a wide variation in treatment method.**

The outcome of non-fatal orthopaedic injury can be improved through the selective use of primary internal fixation of distal radial and humeral fractures and the close adherence to a management algorithm in femoral fractures. There may be a role for more specialised supervision of primary treatment of these particular fractures.

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The main cause of death and hospital admission in children aged 5–16 years in the UK is after accidental injury *(1)* at an annual cost of over £200 million per annum *(2)*. Although childhood mortality rates from accidental injury are gradually declining (currently 80–100 per million boys, 40–60 per million girls), hospital admission rates are continuing to rise. It is surprising, therefore, that little has been published about the patterns and management of non-fatal injury in childhood.

Only acute infections cause more morbidity than trauma in childhood. Great effort has rightly been spent on determining the epidemiological factors governing childhood injury. The specific needs of the severely injured child can be met in specialist regional paediatric trauma units, staffed by paramedic, nursing and medical personnel with paediatric-orientated training. In the UK such a network of regional units and the facilities to transport children quickly to them has not been established. Care is more often provided on a local basis in shared paediatric wards. It is important to ensure, with the establishment and expansion of the Trust hospital philosophy, that appropriate paediatric trauma care can be provided at a local level.

With this in mind, we have conducted an audit of the paediatric orthopaedic trauma service at Southampton General Hospital to evaluate:

The annual workload arising from paediatric trauma.
The patterns of injury that require hospital admission.
Areas where management could be improved.

Methods

An audit was performed of all children, aged under 15 years, who were admitted to the paediatric orthopaedic unit at Southampton General Hospital after accidental injury between 1 September 1993 and 31 August 1994. Children with isolated head and facial injuries were excluded from this audit as they were admitted and managed under the surgical or neurosurgical units.

Data were drawn primarily from that recorded at patient discharge and held on the hospital case mix database. This was cross-referenced against data recorded in the ward admission registers, theatre operation registers, accident and emergency computer database and individual patients' notes and radiographs. In this way data were checked for completeness and accuracy, deficiencies in the computer record were identified and corrected after review of notes and radiographs.

The following information was assessed for each patient:

Age	Diagnosis(es) (ICD9/10 codes)
Sex	Treatment(s) (OPCS code)
Admission date(s)	Mechanism of injury (E-code)
Admission route	Operation date(s)
Admission source	Discharge date(s)

Analysis of the compiled data was performed using an Excel spreadshead database running on an desktop IBM computer. Data fields were first cross-tabulated and then descriptive statistical parameters were calculated for numerical data. Age-specific admission rates were estimated using 1991 population census data for Southampton and South West Hampshire district.

Management was audited by studying the primary conservative and operative treatment methods employed. The relative success or failure of treatment was evaluated in terms of need for secondary operative treatment, salvage internal fixation, length of hospital stay, unplanned readmission and radiographic outcome.

Results

Paediatric trauma workload

In 1993/1994, Southampton General Hospital served an estimated paediatric population under 15 years of age of 79 908 children, representing approximately 18% of the total population of 434 162.

During this period, 398 children (255 boys : 143 girls) were admitted to the paediatric orthopaedic unit with a traumatic injury. Thus, an estimated 50/10 000 of the local paediatric population were admitted annually for orthopaedic care after trauma. In all, 91% were admitted via the accident and emergency (A&E) department, 6% after fracture clinic review, 1.5% after direct referral from the general practitioner and 1.5% transferred from other hospitals and departments.

A marked seasonal variation in admission rate was observed over the year, with a peak admission rate in early summer and a trough in winter (Fig. 1, Fig. 2). The sudden fall in admission rate at the end of October coincided with the change from British summer to winter time. This seasonal variation in admissions was statistically significant ($0.0001 < P < 0.001$) when analysed for cyclical trend using the Kolmogorov–Smirnov statistic (Fig. 2).

Admission rate also varied with the age and sex of patients. Age-specific admission rate plots for each sex (Fig. 3), show a rise for both sexes at independent walking age and a further rise in the early 'teens. This latter increase was more pronounced for boys.

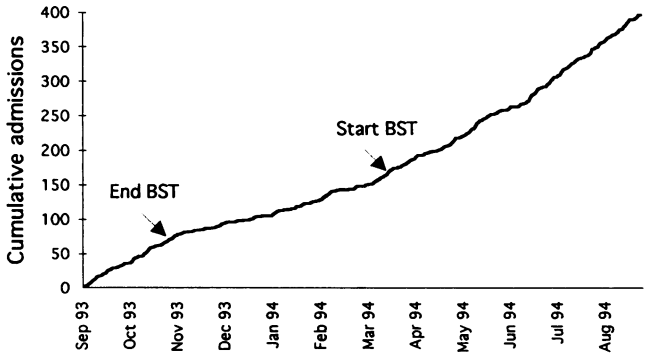

Figure 1. Cumulative admissions of children with orthopaedic injury. (BST = British Summer Time.)

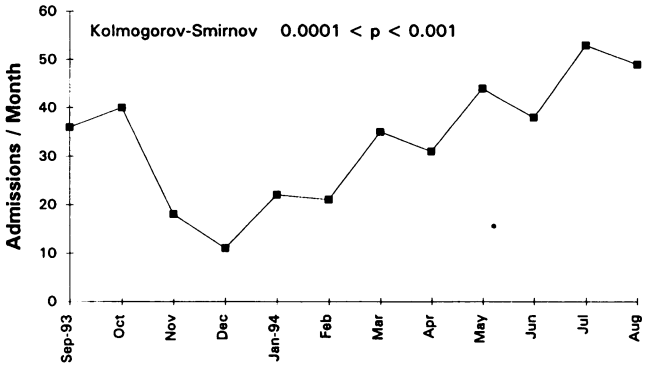

Figure 2. Monthly variation in admissions.

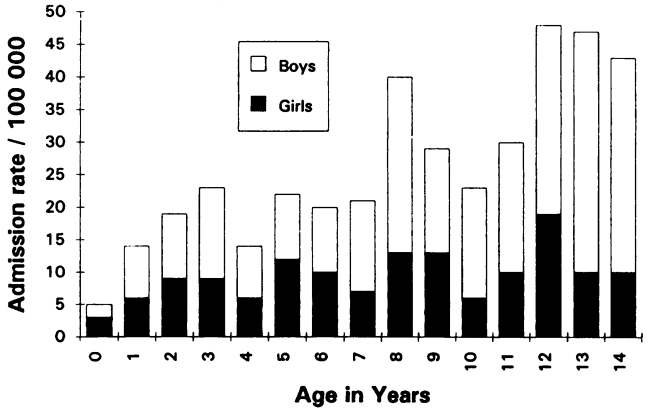

Figure 3. Age-specific admission rates.

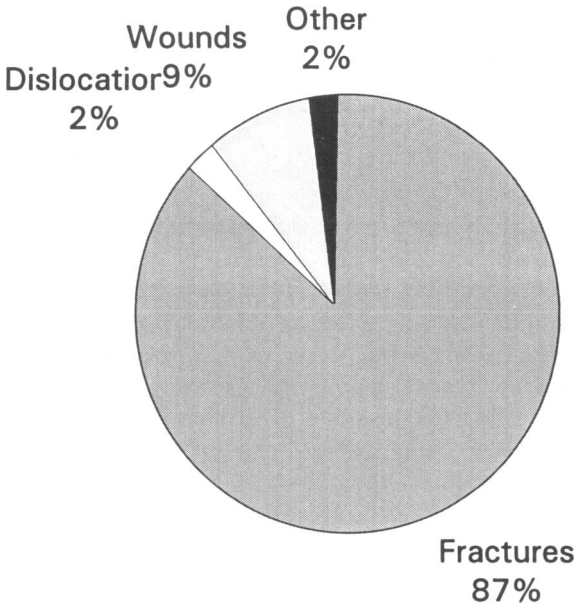

Figure 4. Trauma pattern in 398 children.

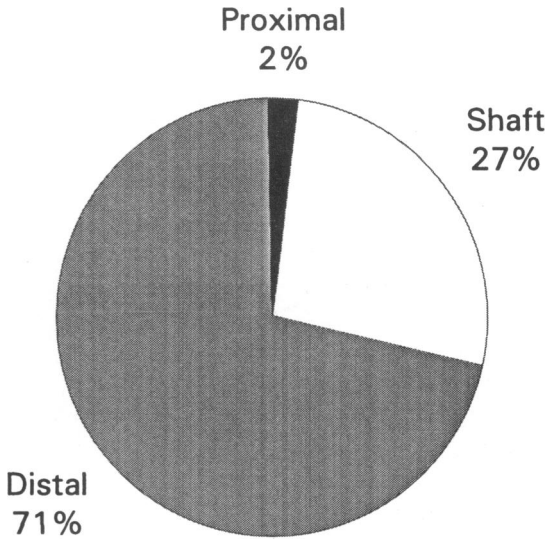

Figure 6. Site of radius/ulna fracture in 217 children.

Nature of orthopaedic injury

The pattern of orthopaedic injuries seen and treated (Figs 4–6) reflected the mechanism of injury and cause (Fig. 7 and Fig. 8).

There were 348 children (87.4% admissions) admitted with fractures, the majority being closed fractures in the upper limb after low-velocity indirect trauma. Fractures of the distal extremity were seen more commonly in both the upper and lower limb. Shaft fractures were more often associated with higher energy trauma in the older child. There were 14 open fractures, eight being phalangeal fractures in children aged under 6 years.

Few infants were admitted with fractures; from the age of 2 years, boys were consistently more likely to be admitted with fractures than girls (m : f ratio of 2.8 : 1) (Fig. 3). The only depatures from this sex ratio were

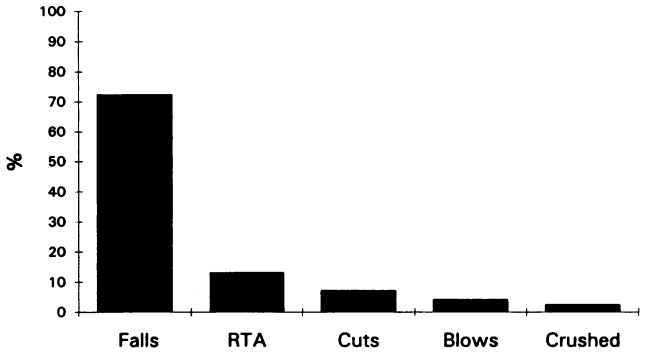

Figure 7. Mechanism of injury.

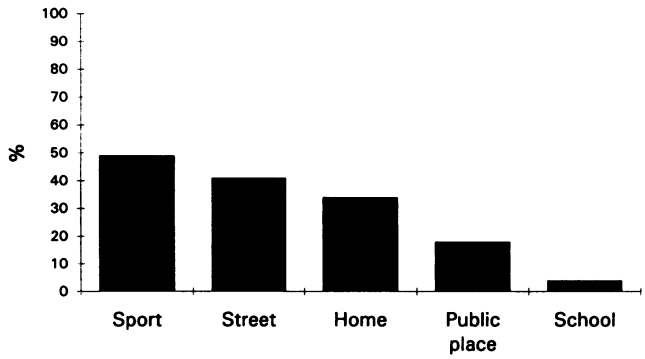

Figure 8. Place of injury.

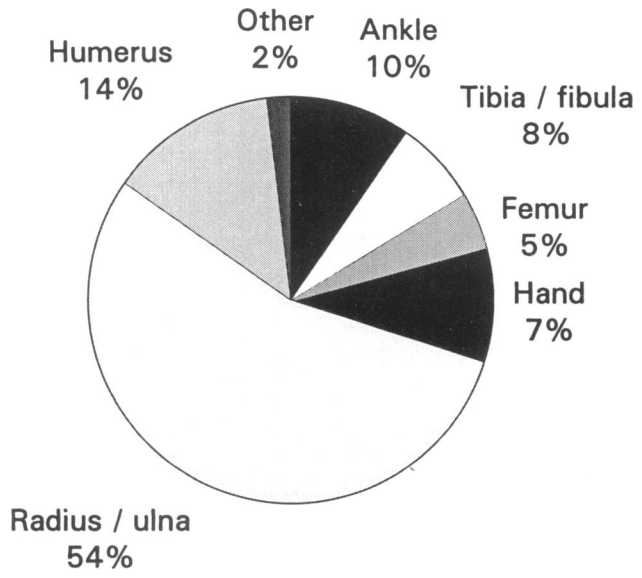

Figure 5. Fractures in 348 children.

observed for tibial shaft fractures (m : f ratio of 8 : 1) and supracondylar fractures of the humerus (m : f ratio of 1 : 2).

In all, 34 children (8.4% admissions) were admitted for management of an open wound or soft tissue injury. These were predominantly to the hand or foot and were treated by wound débridement under general anaesthesia and primary or delayed closure.

There were nine children (2.2% admission) admitted with joint injury, either dislocation or with post-traumatic swelling.

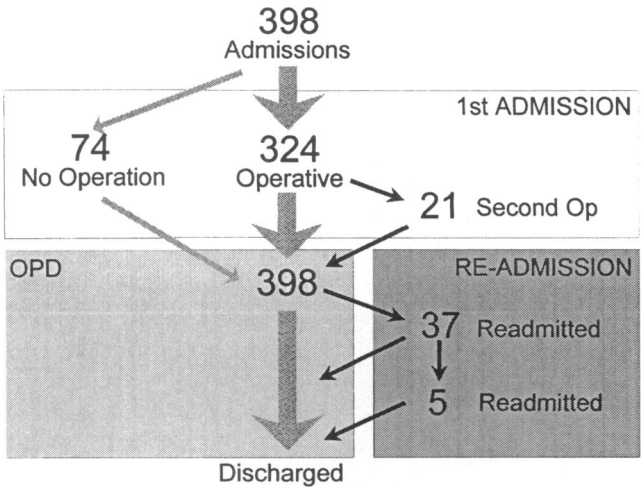

Figure 9. Management of orthopaedic injury within the department.

Management of orthopaedic injury

An overview of the management of 398 children is presented in Fig. 9.

The initial orthopaedic management was operative in 324 children (81%) and usually required general anaesthesia. Of this group of children, 21 subsequently required a further operative procedure during their initial admission. The injuries in 74 children (19%) were managed conservatively with elevation, splintage, traction and plaster casts. There was a zero mortality rate and all 398 children were discharged.

Reoperations and readmissions

Over the year of study, 42 children (12.1% of those with fractures) were readmitted on a further 47 occasions in connection with their original injury. These patients had all sustained fractures of either the distal radius, forearm shaft or distal humerus. These readmissions were unplanned and required either repeat manipulation or secondary fracture stabilisation when initial conservative treatment had failed (Table I).

The highest unplanned readmission rate (19%) was encountered in fractures of the distal radial diaphysis, with 25 children readmitted on 27 occasions as a result of loss of position after closed manipulation and plaster immobilisation. In this group of patients, K-wire stabilisation at readmission improved the anatomical outcome but remanipulation alone did not maintain reduction.

Table I. Primary treatment of fractures and requirement for salvage procedures

Primary management	*No of children*	*Secondary procedures*
MUA + POP	207	34 (16%)
POP alone	65	5 (8%)
Internal fixation	50	0
Traction	9	3 (33%)

Repeat admissions accounted in total for a further 77 bed occupancy days.

Salvage internal fixation

Internal fixation was employed in 70/338 children with fractures (21%) using a variety of operative methods, instrumentation systems and implants. With the exception of the use of a paediatric intramedullary nail, dedicated paediatric designed implants were not required.

Of internal fixation procedures, 29% were performed as 'salvage' after failure of conservatively treated fractures of the distal radial diaphysis ($n=12$), both bone forearm fractures ($n=4$), supracondylar humeral fractures ($n=3$) and femoral shaft fractures ($n=1$). The requirement for salvage fixation further prolonged total inpatient stay by an estimated 64 days.

Prolonged inpatient stay

The majority of children were discharged within 72 h of injury (Fig. 10). The median length of stay in hospital after injury was 1.0 days (range < 1–76 days) and a total of 1210 bed days were occupied over the whole year. Most beds were occupied by children with fractures of the distal radius. Surprisingly, 17 children with femoral fractures (median stay 18 days) occupied more bed days than 217 children with forearm fractures (median stay 1.4 days) (Table II). On detailed analysis, this was attributed to a considerable variation in the management of 11 children with femoral shaft fractures (Fig. 11). This variation appeared to influence anatomical outcome, with a greater degree of shortening seen in the older child treated conservatively with traction methods. In contrast, internal fixation at the outset achieved anatomical union with a shorter inpatient stay (Table III).

Table II. Cost implications of hospital stay for forearm and femoral fractures

Fracture	*Patients*	*Mean stay (days)*	*Bed cost @ £250/day*
Forearm	217	1.4	£74 000
Femur	17	17.9	£76 000

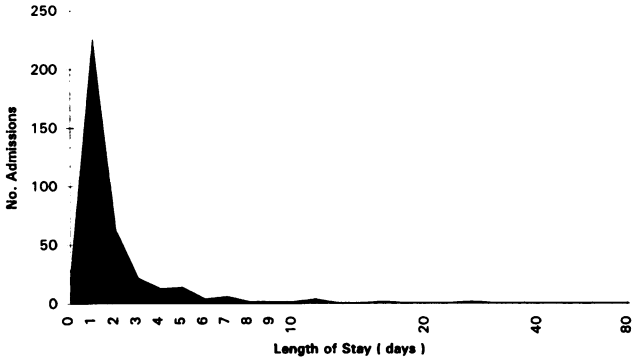

Figure 10. Total inpatient stay.

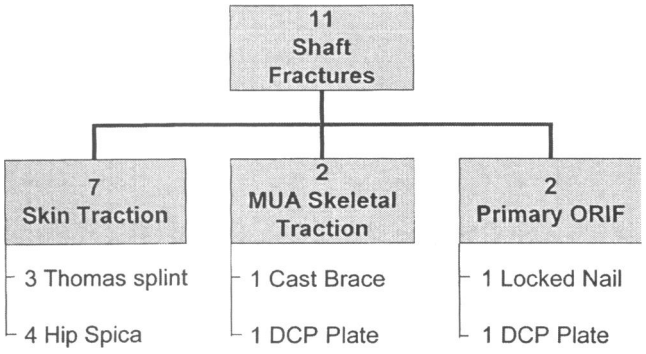

Figure 11. Management of 11 patients with femoral shaft fractures.

Table III. Outcome of patients with femoral shaft fractures*

Primary treatment	*Mean age*	*No of patients*	*Shortening (mm)*	*Hospital stay (mean)*
Hip spica	2.6	4	5	15
Skin traction	8.4	3	10	37
Skeletal traction	13.6	1	18	44
ORIF	12.2	3	0	20

*6/17 patients (mean age 2.8 years) had fractures of the distal femoral metaphysis and were excluded from analysis in this table

Discussion

The true incidence of orthopaedic traumatic injury in childhood is not known, due largely to problems with comparison of data collected from Hospital Inpatient Enquiry, A&E department attendances and National General Practitioner morbidity studies. The 50/10 000 admission rate shown by this audit is lower than national HIPE data *(3)* and that found in a recent survey of accidental childhood injury in Newcastle 166/10 000 *(1)*. However, comparable admission rates have been reported from other centres worldwide (Table IV). The variation seen between units reflects the local provision of hospital services for trauma, health care infrastructure and socioeconomic factors, rather than true epidemiological difference in fracture incidence.

The audit has demonstrated a significant seasonal variation in admission rate that has important implications for bed management and staffing levels. The suggestion from the present study of a link between fracture admissions and available daylight hours is supported by a previous study of children in Dublin *(4)*, where positive correlation between admission of children with fractures and sunshine hours was shown. The regional pattern of childhood limb injury identified in this audit, with a predominance of upper limb and forearm fractures, is well-recognised and appears similar in many societies *(5,6)*.

Three specific areas of concern were identified where it was felt that orthopaedic management could be improved:

1 High rates of reoperation and readmission to the unit.
2 High rate of 'salvage' fixation after failure of conservative treatment.
3 Prolonged inpatient stay for femoral shaft fractures.

Unplanned readmission for additional operative fracture treatment is undesirable, creating stress for both the child and family. It can create an additional burden by overloading trauma lists and by interfering with the elective service.

In common with several recent outcome studies *(7,8)*, the audit has identified a particular problem in the treatment of displaced fractures of the distal radius, with a 19% risk of re-displacement after initial conservative treatment. In particular, failure rates of conservative treatment of up to 60% have been reported in fractures through the diametaphyseal region *(9,10)*, irrespective of the quality of cast immobilisation and experience of the surgeon *(11)*. The problems of re-displacement and the need for subsequent readmission should be reduced through the selective use of primary percutaneous K-wire stabilisation of the displaced fracture in the older child.

However, our radiographic analysis of this fracture pattern in the younger child suggests that the key to maintaining position is accuracy of reduction, in particular restoration of rotational alignment, and this may be more safely achieved in this age group by a well-moulded above-elbow cast.

The total length of inpatient stay over the study period

Table IV. Epidemiological studies of paediatric orthopaedic trauma

Author	*Year*	*Source*	*Mortality rate /10 000*	*Admission rate /10 000*	*Attendance rate /10 000*
Smith *et al.*	1983	Baltimore, USA		72	
Lapidus *et al.*	1980–1986	Connecticut, USA	2.3	95	
Davidson *et al.*	1983–1987	New York, USA		85	
Vane *et al.*	1985–1990	Vermont, USA		35–110	
Pitt *et al.*	1985–1991	Brisbane, Australia	1.3	91	600
Gofin *et al.*	1986	Jerusalem, Israel	0.6	25	980
Pieri *et al.*	1988	Rome, Italy	<0.05% attenders	4.8% attenders	654
Nolan *et al.*	1989	Melbourne, Australia	1.1	65–96	440–640
Peclet *et al.*	1990	Washington, USA	2.0	90	

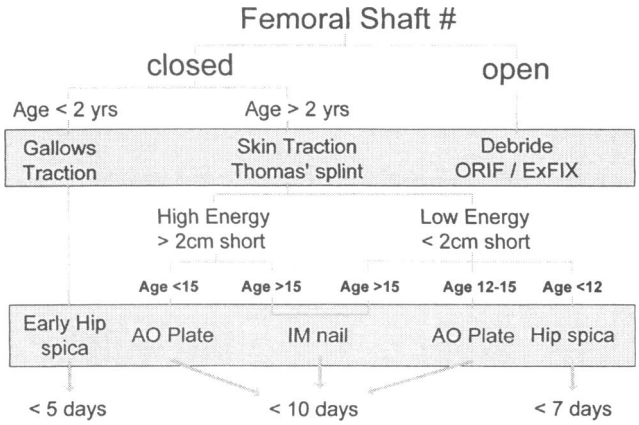

Figure 12. Algorithm for femoral shaft fracture management.

was largely determined by the few patients with femoral shaft fractures. Although constituting less than 2% of all paediatric bony injuries *(12)*, the resource consumption of femoral shaft fractures is considerably higher than all other childhood fractures *(13,14)*. At Southampton, an algorithm is employed in the management of paediatric femoral fractures according to the age of the patient, energy of injury and pattern of fracture (Fig. 12), goals being to rationalise safe management and to streamline for early hospital discharge. The recent introduction of flexible intramedullary nails may modify this algorithm. The poor outcome and estimated increase in hospital stay of 190 days for the 17 patients with femoral fractures arose principally through a failure to adhere to this algorithm.

We believe this audit has shown that salvage internal fixation of paediatric fractures is an important issue. The relatively high incidence may reflect the uncertainty that surrounds the primary treatment of particular fractures. In this respect, a case could be made for more specialised supervision of primary treatment.

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Received 7 April 1997