ORIGINAL ARTICLES

DESTINATION OF DEBRIS DURING INTRAMEDULLARY REAMING AN EXPERIMENTAL STUDY ON SHEEP FEMURS

J.P.M. FRÖLKE, H. VAN DE KROL, F.C. BAKKER, P. PATKA, H.J.T.M. HAARMAN

This study was designed to further explain the better fracture healing in fractures treated with a reamed nail. It investigates the location and quantity of the reaming debris in an ex vivo animal model to test the autograft theory.

In 10 cadaveric sheep femurs, a 5-mm semicircular gap was created at the midshaft. The medullary cavity was opened and the reaming debris that dropped from the gap during reaming and the debris from the proximal opening were collected and weighed separately.

The mean harvest of reaming debris at the gap was 0.99 g ± 0.12 g (24%) and from the proximal opening at the medullary cavity 3.08 g ± 0.31 g (76%) (total 4.07 ± 0.34 g).

This study proves that a significant amount of reaming debris collects at an artificial fracture gap during reaming of the medullary cavity. This finding supports the theory of bone autografting.

Key words : long bones ; fracture ; intramedullary reaming ; nailing ; reaming debris ; autografting

Mots-clés : os longs ; fracture ; alésage médullaire ; enlouage ; débris d'alésage ; autogreffe

INTRODUCTION

Intramedullary reaming is less controversial than it was a few years ago. Since prospective clinical studies have recently pointed out that fractures heal faster when treated with a reamed nail [1, 2, 5, 7, 10, 15], research has focused with renewed interest on the exact pathophysiological mechanism.

One explanation could be the collection of reaming debris at the fracture site, a phenomenon that has been compared to autografting. Most studies recognize the value of the reaming debris as a stimulator of fracture healing [6, 8, 9, 12, 16], whereas a few others show a negative effect [3, 11]. Reaming debris has been proven to contain vital tissue from which bone cells grow as fast as bone cells from cancellous bone from the iliac crest [8,17]. All these studies however do not provide any proof that reaming causes a deposition of reaming material in the fracture area [14].

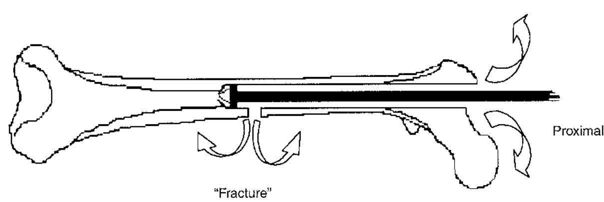

Fig. 1. — Illustration showing the model that was used to measure the destination of reaming debris in 10 sheep femurs. Arrow with "fracture" indicates the place where reaming debris collects at the fracture site, whereas arrows with "proximal" indicate the place where reaming debris is lost through the working channel of the reaming tool.

It is indeed not unlikely that reaming debris, which is moved up and down with the reamer under a certain pressure during reaming of the medullary cavity, collects at the place of least resistance. This can be at the opening in the proximal cortex, made to insert the reaming tool, or at the fracture site. The first step in understanding the influence of

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autografting on fracture healing is how much debris actually settles in the fracture gap during reaming of the medullary cavity.

Therefore this study was designed to investigate the location and quantity of reaming debris in order to test the concept of autografting. To achieve standard conditions, an experimental model was used.

MATERIALS AND METHODS

Ten healthy adult female sheep with the same age and with a weight of 60-80 kg were used. They were sacrificed and their femurs were explanted and kept in 70% alcohol. The femurs were warmed up to 38° C (normal body temperature in sheep) prior to the following procedure: A 5-mm semicircular gap was created with a saw and chisel at the concave side of the midshaft. The femur was mounted in a working bench with the gap oriented downward, to provide the maximum effect of gravity (fig. 1). The medullary cavity was opened with a 13-mm bore at the trochanteric side. The medullary contents were sucked off and washed out with plain water. Subsequently the medullary canal was reamed by taking 0.5-mm steps with the same technique as used in humans with standard power tools (Mathys Medical Nederland BV, Den Dolder, The Netherlands) and with a standard Gray reamer (Stryker Howmedica Osteonics Gmbh, Kiel, Germany). When resistance at the isthmus was noted, two more millimeters were reamed. The reaming debris that dropped from the gap during reaming and the debris from the proximal opening were collected and weighed separately. Results are expressed as means ± standard error of the mean (SEM).

RESULTS

In the 10 sheep femurs that were used in this study, the mean maximum diameter of the reamer was 16.5 mm. The mean harvest of reaming debris at the gap was 0.99 g ± 0.12 g (24%) and from the proximal opening 3.08 g ± 0.31 g (76%). The total amount was 4.07 ± 0.34 g (fig. 2).

DISCUSSION

Tydings *et al.* in 1986 were the first to postulate that a local deposition of reaming debris in the fracture gap from reaming the medullary cavity could stimulate fracture healing. The same investigators showed a year later the components of reaming debris, which consists of marrow fat, blood and bone scrapings [17]. They again suggested an osteoinductive effect of this material. In another study, bone cell cultures showed active cell growth from the reaming debris similar to cancellous bone from the iliac crest in sheep [8]. The destination of reaming debris presented in this study is the first step in understanding the theory of autografting [14].

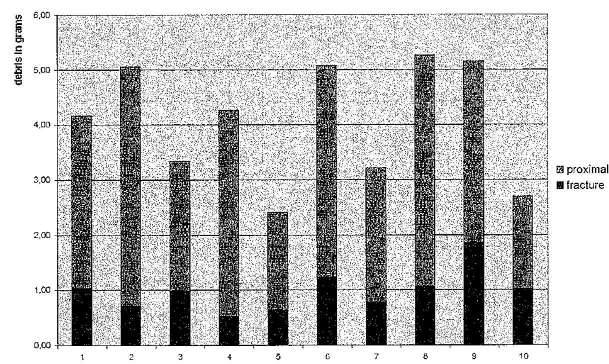

Fig. 2. — Amounts of reaming debris in grams per sheep femur, weighed separately from the artificial fracture gap ("fracture") and from the proximal opening in the medullary cavity ("proximal").

We developed this model to quantify the amount of debris at an artificial fracture gap from reaming. This semicircular gap of 5 mm can be compared with a true simple, transverse fracture with 2.5 mm distraction. We found a percentage of 24% of the total amount of reaming debris at the gap, but depending on the size of the fracture cleft and the amount of distraction in a real fracture situation, the amount of reaming debris may vary.

The reamer that we used was a standard reamer with a star-shaped tip, which is designed to minimize intramedullary pressure by leaving room for the evacuation of blood and reaming debris [13]. The smaller the evacuation of this debris through the proximal opening, the more debris will settle at the fracture gap. With a reamer with a flat extremity such as the AO/ASIF reamer (Synthes, Switzerland), the amount of reaming debris at the fracture gap may increase [14]. Therefore, we assume that the 24% of the total amount of reaming debris that we found at the artificial fracture gap is a minimum.

We also have to keep in mind the anatomical differences between human and sheep femurs. The human femur contains more cancellous bone than the sheep femur, which implies that the bone reamings from humans will contain relatively more cancellous bone, which is known to stimulate fracture healing [4].

CONCLUSION

This study demonstrates that a significant amount of reaming debris collects at an artificial fracture gap, which supports the theory of bone autografting.

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SAMENVATTING

J.P.M. FRÖLKE, H. VAN DE KROL, F.C. BAKKER, P. PATKA AND H.J.T.M. HAARMAN. De verplaatsing van boormeel tijdens het ruimen van de mergholte — een experimentele studie met schapen femora.

In deze studie wordt gezocht naar een pathofysiologische verklaring waarom fracturen, behandeld met een geboorde intramedullaire grendelpen, beter genezen dan fracturen, behandeld met een ongeboorde pen. In het kader van de "autograft" theorie wordt beoordeeld aan de hand van een kadaver femur model, of er voldoende boormeel in de fractuur terecht komt om deze theorie te steunen.

Ter hoogte van de isthmus van 10 kadaver femora van schapen werd een halfcirkelvormig defect gezaagd van 5 mm breed. De mergholte werd proximaal geopend en tijdens het opboren van de mergholte werd het boormeel, dat via het botdefect en via de proximale opening naar buiten kwam, opgevangen en gewogen.

De gemiddelde hoeveelheid boormeel dat opgevangen werd via het botdefect was 0.99 g $\pm$ 0.12 g (24%) en via de proximale opening van de mergholte 3.08 g $\pm$ 0.31 g (76%). In totaal was de hoeveelheid boormeel 4.07 $\pm$0.34 g. Deze studie laat zien dat een aanzienlijke hoeveelheid boormeel terecht komt in een kunstmatige fractuurspleet tijdens het opboren van de mergholte. Deze bevinding ondersteunt de "autograft" theorie.

RÉSUMÉ

J.P.M. FRÖLKE, H. VAN DE KROL, F.C. BAKKER, P. PATKA AND H.J.T.M. HAARMAN. Destination des débris générés par l'alésage médullaire : étude expérimentale sur le fémur du mouton.

Cette étude a été réalisée pour éclaircir certains points concernant la consolidation des fractures traitées par enclouage après alésage. Elle a porté sur la destination et la quantité de débris d'alésage, sur un modèle animal in vitro (fémur de mouton), pour tester la vraisemblance de l'hypothèse selon laquelle ces débris peuvent agir comme une autogreffe. Une perte de substance de 5 mm a été réalisée sur une demi-circonférence, dans la région médio-diaphysaire, au niveau de 10 fémurs de mouton. Après ouverture de la cavité médullaire, les fémurs ont été alésés et les débris d'alésage expulsés par le défect osseux d'une part, par l'ouverture proximale d'autre part, ont été récoltés et pesés séparément. On a récolté en moyenne 0,99 gr ± 0,12 gr (24% des débris) au niveau du défect, simulant la fracture, et 3,08 gr ± 0,31 gr (76% des débris) au niveau de l'orifice d'entrée proximale dans la cavité médullaire.

Ce travail montre qu'une quantité appréciable de débris d'alésage est parvenue au niveau d'un foyer de fracture artificiel au cours d'un alésage de la cavité médullaire. Cette constatation vient à l'appui de la théorie de l'autogreffe osseuse.