Audit of bone marrow trephines

P W Bishop, K McNally, M Harris

Abstract

***Aims*: To establish criteria of adequacy for bone marrow trephine biopsy specimens and to audit the quality of trephines performed at the Christie Hospital, Manchester.**

***Methods*: Trephines (n = 767) performed over 12 months were reviewed. Their lengths, and the lengths of their constituent parts (soft tissue, cortex, crushed marrow and interpretable marrow) were measured. The mean performance of each operator was calculated. Criteria of adequacy were established by a review of the published findings and an analysis of the relation between trephine length and the rate of infiltration by tumour.**

***Results*: Before processing, the average trephine was 1·59 cm long. Trephines shrunk by 25% during processing. In histological sections the average length was 1·15 cm, consisting of 0·09 cm of soft tissue, 0·04 cm of cortex, 0·26 cm of disrupted marrow and 0·74 cm of interpretable marrow. A large number of operators were taking trephine biopsy specimens and their performance varied considerably. Review of the published findings suggested that the minimum adequate length is in the range 1·5 cm to 2·0 cm. The analysis of the relation between length of trephine and the rate of positivity for neoplasia yielded a minimum adequate length of 1·2 cm in section (1·6 cm before processing). Fifty eight per cent of the trephines were inadequate by this criterion. There was a tendency for the Jamshidi needle to produce a longer trephine than the Islam needle.**

***Conclusion*: According to objective criteria, at the Christie Hospital, many operators are producing a high proportion of inadequate bone marrow trephines.**

(*J Clin Pathol* 1992;45:1105–1108)

Department of Histopathology, Christie Hospital, Manchester
K McNally
M Harris

Department of Pathological Sciences, University of Manchester
P W Bishop

Correspondence to:
Dr P W Bishop, Department of Pathology, Christie Hospital, Wilmslow Road, Manchester M20 9BX

Accepted for publication
8 July 1992

The Christie Hospital, Manchester, is the regional referral centre for radiotherapy and chemotherapy for the north west of England. A large number of bone marrow trephines are therefore performed. It is impractical for these all to be carried out by members of the department of haematology, so the work is devolved to staff within each clinical department. This audit was undertaken because of a subjective impression within the department of histopathology that many of the trephine biopsy specimens received are of poor quality. Many appear to be small or show crush artefact. The aims of the audit were to establish criteria of adequacy and to substantiate or refute this subjective impression, to investigate reasons for inadequacy and to suggest remedies.

Methods

The study period ran from 1 June 1990 to 31 May 1991. The trephine biopsy specimens received in the histopathology department, both those performed within the Christie Hospital, and those sent from elsewhere for review, were ascertained from the department's day-book. Slides and request cards were retrieved from file. In the spring of 1991, a short questionnaire had also been distributed with the trephining equipment, asking the operator to record his name, the type of needle used and any problems experienced in performing the trephine biopsy; this information was incorporated in the study.

It has been the practice for medical laboratory scientific officers (MLSOs) to record the lengths of trephine biopsy specimens after fixation and before paraffin wax embedding: this measurement is made with a metric rule. Where the MLSO recorded a trephine biopsy specimen as being in several pieces, the total length has been used in this study. The lengths of trephines in histological sections were also ascertained; again, where a trephine was in several pieces, the total length was recorded. The lengths of the component parts (soft tissue, bone cortex, subcortex, crushed hae-

Mean lengths (cm) of components of trephines produced by each operator who performed more than five, ranked by the number performed

Number performed	Soft tissue	Cortical bone	Crushed marrow	Intact marrow	Total length
6	0·03	0·15	0·14	0·07	0·39
6	0·02	0·05	0·32	0·37	0·76
6	0·15	0·07	0·15	0·58	0·95
6	0·12	0·12	0·31	0·65	1·20
6	0·04	0·05	0·55	0·67	1·31
7	0·14	0·03	0·39	0·54	1·10
8	0·04	0·04	0·21	0·56	0·85
8	0·05	0·04	0·40	0·39	0·88
8	0·13	0·10	0·46	0·44	1·13
9	0·07	0·03	0·55	0·27	0·92
9	0·06	0·03	0·23	0·74	1·06
10	0·06	0·03	0·24	0·43	0·76
12	0·05	0·18	0·27	0·28	0·78
12	0·06	0·06	0·30	0·96	1·38
13	0·01	0·00	0·13	0·59	0·73
15	0·04	0·03	0·33	0·30	0·70
19*	0·09	0·06	0·23	0·97	1·35
20	0·03	0·02	0·22	0·61	0·88
22	0·11	0·15	0·26	0·20	0·72
22	0·08	0·01	0·19	0·51	0·79
24	0·23	0·05	0·15	1·09	1·52
28	0·19	0·04	0·15	1·07	1·45
28	0·10	0·06	0·27	1·82	2·25
33	0·09	0·05	0·23	0·33	0·70
36	0·19	0·06	0·24	0·64	1·13
37	0·16	0·04	0·41	0·43	1·04
51	0·01	0·02	0·33	1·17	1·53
55	0·04	0·03	0·25	0·97	1·29
68	0·08	0·06	0·29	0·99	1·42
75	0·06	0·02	0·22	0·61	0·91

The row marked with an asterisk is the averaged pooled trephines performed outside of the Christie Hospital and sent for review.

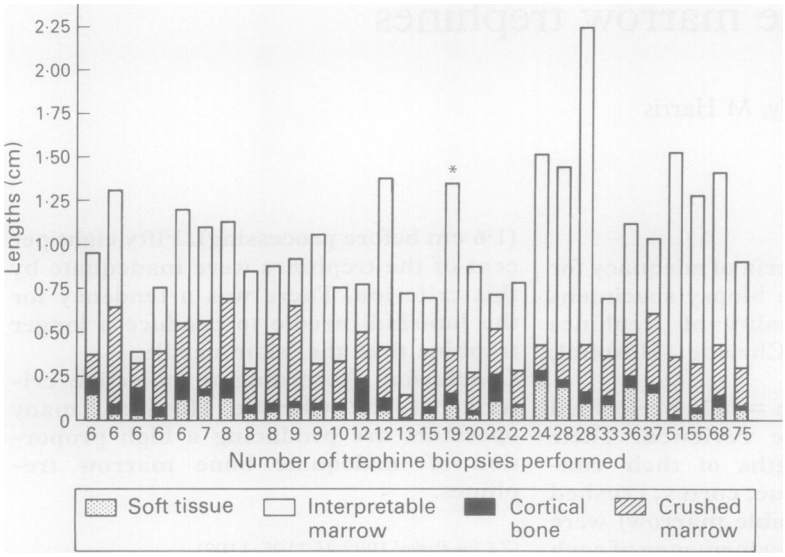

Figure 1 Mean lengths of the components of trephine biopsy specimen produced by each operator who performed more than five, ranked by the number performed. The bar stack marked with an asterisk is the averaged pooled trephine biopsies performed outside of the Christie Hospital and sent for review.

mopoietic marrow and interpretable haemopoietic marrow) were measured using an eyepiece graticule. These measurements were made without knowing the identity of the operator who performed the trephine biopsy.

The operator who had performed the trephine biopsy was assumed to be the person signing the request card. Where signatures were illegible, they were photocopied and each signature was allocated a code number.

Results

Trephines (n = 767) were identified from the day-book. This constitutes 11% of the workload of the histology department. Slides were available on all but five and request cards on all but 36 of those ascertained from the day-book.

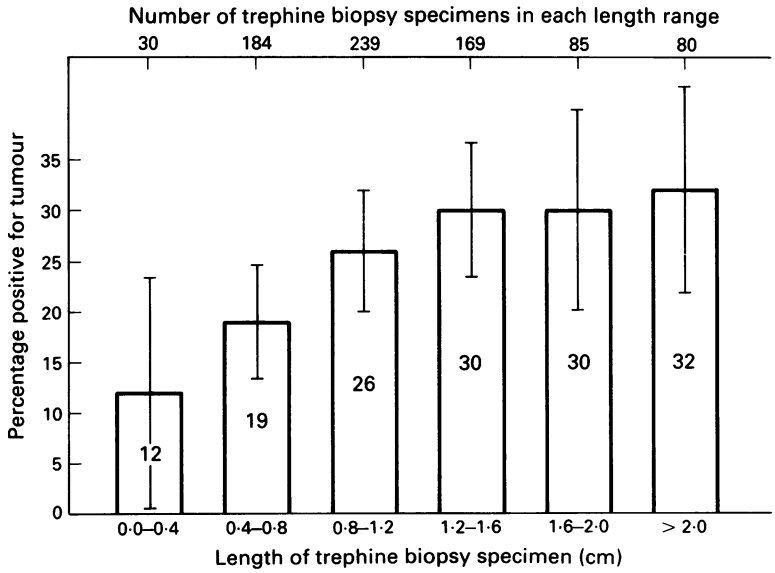

Figure 2 The percentage of trephine biopsy specimens positive for tumour plotted against the length of the trephine in 0·4 cm increments: 95% confidence limits for each bar are shown.

The average length of trephine biopsy specimen recorded by the MLSOs was 1·59 cm (95% cl 1·52–1·66 cm). The average total length of a trephine in histological section was 1·15 cm (cl 1·10–1·19 cm). This amounted to an average shrinkage of 29% during processing and sectioning. The shrinkage was partly accounted for by the presence of blood clot on the trephine, which leads to an overestimate of the length of the trephine: in those 170 cases in which blood clot was present, the average length measured by MLSOs was greater, at 1·86 cm (cl 1·68–2·02 cm), with an average length in section of 1·16 cm (cl 1·07–1·24 cm), a shrinkage of 37%. However, even when no blood clot was seen in the section, there was an average shrinkage of 25%, from 1·51 cm (cl 1·44–1·57 cm) to 1·12 cm (cl 1·07–1·17 cm), during processing. All measurements given thereafter were made on histological sections and are therefore comparable; they should be multiplied by a factor of 1·33 to correct to the lengths before processing.

The average length of each component in histological section was: soft tissue 0·09 cm (cl 0·07–0·11 cm); bone cortex 0·04 cm (cl 0·03–0·05 cm); disrupted marrow 0·26 cm (cl 0·24–0·28 cm); and interpretable marrow 0·74 cm (cl 0·70–0·78 cm). Hypocellular subcortex could only be identified with certainty in a small proportion of trephine biopsy specimens and its contribution to the average length was negligible; this component was not analysed further.

Thirty operators were identified who had performed more than five trephines during the study period. The average component lengths for each operator who had performed six or more trephines are shown in fig 1, ranked by the number of trephines performed.

Figure 2 shows the proportion of trephines with marrow infiltration by tumour, plotted for 0·4 cm increments of the total trephine length. The proportion positive for tumour shows a rising curve to a plateau of about 30% at a length of at least 1·2 cm. A similar plot against the length of interpretable marrow showed a plateau at 0·8 cm. Similar curves, with the same threshold for the plateau are seen if trephines are restricted to 295 cases of non-Hodgkin's lymphoma. No other specific diagnostic category was available in sufficient abundance for analysis. Because leukaemia affects the marrow more diffusely than other malignant neoplasms, the analysis was also performed on all cases of malignant neoplasia excluding 66 myeloid leukaemias; the shape of the curve was not significantly altered.

The relative merits of the Jamshidi and Islam needles were investigated. Data were available for 71 trephines known to have been performed with Jamshidi needles and 23 known to have been performed with Islam needles. The Jamshidi produced a trephine biopsy specimen which was on average 0·22 cm (cl -0·03–0·47 cm) longer, with 0·11 cm (cl -0·13–0·43 cm) more interpretable marrow. Nine of 94 of operators reported some fault in the equipment—bent or blunt

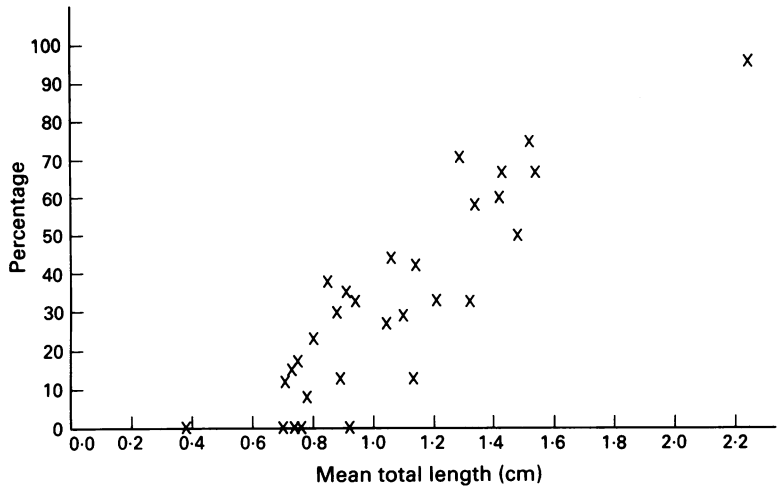

Figure 3 The percentage of adequate trephine biopsies by each operator plotted against the mean length of the trephines produced by the operator.

needles, or missing equipment. A further nine of 94 operators reported difficulty removing the core from the trephine needle. For both types of needle, a report of any difficulty was associated with a shorter trephine (average 1·02 cm (c1 0·84–1·20)) and an even more reduced length of useful trephine (average 0·51 cm (c1 0·33–0·70 cm)).

Discussion

Bone marrow trephine biopsy is an important complement to marrow aspiration. For example, Jamshidi and Swain found that in 14%–16% of cases it yielded a diagnosis which was not apparent on the smear alone.[1] However, to carry out many trephine biopsies is expensive in terms of clinicians' and laboratory time, in materials used, and in discomfort to patients. These considerations, combined with our subjective impression that many of the trephines are inadequate, makes it an appropriate subject for medical audit. Bone marrow trephines are also unusual among histological specimens in that a simple numerical measurement of adequacy, the length of the trephine, can be made. There has been a small comparative study by Ioannides and Rywlin of the quantity of marrow obtained by aspiration and by two types of trephine needle.[2] The study used a morphometric point counting technique to determine the surface area of marrow available for examination. We elected to use a simpler assessment of trephine component lengths because of the large number of trephines which we wished to assess.

Before the adequacy of the trephine biopsy specimens under review can be assessed, criteria of adequacy need to be established. Published findings give some guidance, although the recommendations often appear arbitrary. We are unaware of any study which has had the primary aim of addressing this question. Brynes *et al* state that an adequate biopsy specimen is greater than 1·5 cm in length,[3] but reference no evidence. Jamshidi and Swain reported the use of their needle to obtain 150 trephines.[1] These had a size range of 0·5–3·5 cm, with an average of 2·0 cm. All the trephine biopsy specimens had well preserved architecture. Smaller specimens were obtained by doctors performing biopsies for the first time. Islam stated that an adequate size is 1·8–2·0 cm.[4] Islam's experience with the Jamshidi needle was that the cores obtained were typically 1·0–1·2 cm long. This was due to fracturing of the core with the result that a part of its length was lost when the needle was withdrawn. It was to overcome this problem that he proposed the design of needle which has come to bear his name. Wintrobe, without citing evidence, gives a minimum length for an "optimum" trephine of 2·0 cm.[5] He also cites a wet weight of 150 mg. Ellis *et al* state that an optimum length is 3/4 inch with a wet weight of 150 mg.[6] Although unattributed, they are probably quoting an earlier edition of Wintrobe. Frisch *et al* state that a minimal biopsy size for diagnostic evaluation is 1·5 cm or five marrow spaces.[7] Others give detailed instruction on trephining technique but offer no guidance on adequacy.[8] Brunning *et al* compared bilateral with unilateral iliac crest trephining and found that bilateral trephining yielded an extra 11%–22% of positive biopsy specimens[9]; the degree of sampling is therefore shown to be of importance. They state that in 10 of 353 cases one or both trephines were inadequate, but do not state their criterion of adequacy.

There is likely to be some variation as to what constitutes adequacy, depending on the spectrum of diseases in the patients from which the trephine biopsy specimens are obtained. We have therefore sought to establish a minimum adequate length for the patient population treated at the Christie Hospital. One would expect the proportion of trephine biopsy specimens which are positive for tumour to increase with an increasing length of trephine, reaching a plateau for trephines of adequate length. This was indeed our finding (fig 2). We analysed the correlation between positivity for tumour and trephine length for specimens from a population of patients with a large range of malignant neoplasia. This included patients with carcinoma, melanoma, sarcoma, lymphoma and leukaemia. Ideally this analysis should be performed separately for each major category of malignant neoplasm. The numbers of cases available prevented us from doing so, except for the category of non-Hodgkin's lymphoma (all subtypes). We consider that the length of trephine biopsy specimen for which the plateau rate of positivity for tumour is achieved represents an objective measure of adequacy. Correcting for shrinkage during processing, for the mix of neoplasms treated at the Christie Hospital, a trephine biopsy specimen needs to be a least 1·6 cm long before processing, with 1·1 cm of interpretable marrow, to detect reliably marrow infiltration by tumour.

On these criteria, 58% of the trephine biopsy specimens are of inadequate total length, 59% have an inadequate length of interpretable marrow, and most operators are producing an inadequate average trephine. Although there is

variability in the individual trephines produced by any one operator, the proportion of adequate trephines from an operator rises sharply with the average length of trephine produced by that operator (fig 3). We are aware that our hospital is unusual in the large number of operators, with a great variation among operators in their experience of performing trephines. Most hospitals will have fewer, more experienced, operators. This is reflected in the average length of the trephines produced outside of the Christie Hospital and sent to us for histological review (fig 1), most of these being performed in district general hospitals by haematologists.

The subjective impression reported by operators is that the Jamshidi needle is superior to the Islam needle. This is the trend of our results, although the 95% confidence limits for the mean total and the mean useful lengths obtained with the two needles overlap.

Our recommendations were that there needs to be an improvement in the training of operators. An instructional video should be made available. An operator who is in doubt as to his ability should seek tuition and one author (PWB) would confidentially inform any operator of his performance. Six months after this audit was presented to the hospital medical staff there have been no enquiries. The audit should be repeated after a period of 12 months to assess improvement.

Addendum

The contents of this paper were presented to the medical staff of the Christie Hospital in September 1991. A preliminary analysis of 232 trephines performed in the first four months of 1992 shows a substantial improvement in the lengths as measured by the MLSOs before processing, to a mean of 2·12 cm. The proportion which are inadequate on grounds of total length has fallen to 25%. More detailed analysis by operator will be needed to establish whether individual operators have improved their performance, or whether a higher proportion of trephine biopsy specimens are now being performed by the more able operators.

We thank Mrs H Clark for distributing the questionnaires with the trephining equipment and Dr Morgenstern and Dr Chang for permitting us to use the resulting data.

1 Jamshidi K, Swain WR. Bone marrow biopsy with unaltered architecture: a new biopsy device. *J Clin Lab Med* 1971; 77:335–41.
2 Ioannides K, Rywlin AM. A comparative study of histologic sections of bone marrow obtained by aspiration and by needle trephine. *Am J Clin Pathol* 1976;**65**:267.
3 Brynes RK, McKenna RW, Sundberg RD. Bone marrow aspiration and trephine biopsy. An approach to a thorough study. *Am J Clin Pathol* 1978;**70**:753–9.
4 Islam A. A new bone marrow biopsy needle with core securing device. *J Clin Pathol* 1981;**35**:359–64.
5 Wintrobe MM. Origin and development of the blood and blood-forming tissues. In: *Clinical haematology.* 8th edn. Philadelphia: Lea and Fegiger 1981:61.
6 Ellis LD, Lee RE, Krause JR. General principles. In: Krause JR, ed. *Bone marrow biopsy.* New York: Churchill Livingstone, 1981:5.
7 Frisch B, Lewis SM, Burkhardt R, Bartl R. Introduction. In: *Biopsy pathology of bone and bone marrow.* London: Chapman and Hall Medical, 1985:10.
8 Dacie JV, Lewis SM. Bone marrow biopsy. In: *Practical haematology.* 6th edn. New York: Churchill Livingstone, 1984:120–1.
9 Brunning RD, Bloomfield CD, McKenna RW, Peterson L. Bilateral trephine bone marrow biopsies in lymphoma and other neoplastic disease. *Ann Int Med* 1975; **82**:365–6.