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INTRAOPERATIVE BIOPSY AND ASPIRATION OF BRAIN LESIONS UNDER ULTRASOUND GUIDANCE - PRELIMINARY STUDIES

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Introduction:

Biopsy of intracranial masses and aspiration of abscesses are important techniques in the management of pathologies affecting the brain.CT scanning is used to detect the presence of a lesion and its approximate location.

Intraoperatively however actual localisation of a lesion commonly has been done in two ways.Firstly by rough approximation using the CT scan images and bony landmark as a guide and secondly by CT stereotaxis.The first technique is inexpensive but unfortunately not very accurate.Small lesion may be missed.For abscess aspiration,patient often require repeat CT scanning and often require repeat operations.CT stereotaxis is excellent for localisation but is expensive and cumbersome.The patient need to be rescanned and then transported to the operating theatre from the CT suite without any relative change in position between the patient and the stereotactic equipment.Any change in position require the patient to be rescanned and the stereotactic equipment adjusted accordingly.

U/S guided biopsy and aspiration has the potential to play an important role in the localisation of the intracranial lesion.It is much less expensive than CT stereotaxis but is much more convenient to use and can be

highly accurate.An added advantage not possible with the other techniques is that it can be used to monitor any haemorrhage or change in size of the lesion during the operation.Thus success or failure of the procedure can be ascertained immediately.

The use of fixation devices to facilitate U/S guided aspiration and biopsy has also been described in the literature.A commercially available fixation device(ie the berger neurobiopsy device) is available in the United States and has been said to be a great aid in the biopsy and aspiration of brain lesions.

This project is the first part of the two phases that is required to study the usefulness and effectiveness of using U/S guided biopsy and aspiration in brain pathologies.

In this phase the emphasis will be on the development and design of an instrument which can be used with the ultrasound transducer to fixate the direction and depth to which to make the biopsy or aspiration.Designing this fixation device will enable us to use the available ultrasound machine we have.We also believe it will also be cheaper compared with buying the Berger neurobiopsy device outright.

Materials and Methods:

A fixation device was designed. This was done with the collobaration of the mechanical engineering section of Jabatan Pembangunan Hospital Universiti Sains Malaysia.
Machining of this device was done at a private engineering firm locally.An exploded diagram and technique of using the instrument is shown in Fig 1.

The most suitable ultrasound transducer(UST - 974 - 5;5mhz) compatible with the available ultrasound machines (Aloka SSD 630 and SSD 300 [portable]) was purchased.The transducer head has a surface area of $2.2cm^2$(2.2 X 1cm).

To test the accuracy and feasibility of using this equipment
several experiments were designed.

a.biopsy of specimens of varying sizes and at different depths using the fixation device and ultrasound guidance.

Plasticine pallets of known and different sizes were placed under slabs of soft tissue(cattle liver). Ultrasound guided biopsies were attempted. Five attempts were made per size of plasticine.Size of specimens range from 0.5cm to 3.0cm.This was also tested for different depth of soft tissue ranging from 1 cm to 4cm.

b.visualization of lesion at different size of burr holes.

Different size rounded holes were made on a 1cm thick cardboard.A plasticine pellet(1.0cm) was placed at a certain depth of soft tissue.The cardboard with the hole in the centre was placed over the soft tissue.The ultrasound transducer within the fixation device was angulated maximally to visualise the specimen.The most lateral position of the specimen seen relative to the centre was recorded at different size holes.

Findings:

The relationship between the depth and size of specimen and accuracy is shown in fig 2.

It is obvious that up to a depth of 4 cm which was tested, the technique is accurate with no misses detected.The size of the sample appear more critical.Specimens of 1 cm or more are punctured with 100% accuracy.However there are frequent misses with specimens of 0.5 cm even at 1 cm depth.

Another limiting factor to successful biopsy is the size of the burr hole.Too small a burr hole will limit the visibility of a lesion. With the present ultrasound transducer, a 1.0cm burr hole proved to be inadequate.

The relative position of the lesion with respect to the position of the burr hole is also important. As shown in Table 1,there is a limit to the visibility of the plasticine sample when it is placed lateral to the burr hole.A deeper sample can be visualised more laterally compared with a shallower sample for a given burr hole size.

Discussion.

Prior to the availability of guidance techniques, the neurosurgeon has to depend solely on approximate localisation from CT scan images.This not only carried a poor diagnostic yield but also has high morbidity and even mortality.Multiple attempts often have to be made to "hit" the lesion with consequent damage to the brain.The smaller and deeper the lesion, the greater the chance of negative sampling. In a recent study, the overall success rate was only 64.9%(1).Even in the largest and most superficial lesion,it never rose more than 88%.(1-2)

Intraoperative cranial ultrasound was first used by Walker(3) in 1966.However it did not gain popularity due to the bulky probes and poor image quality.Later, CT guided stereotaxy (and now MRI guided stereotaxy) were introduced and they were very successful.

Intraoperative ultrasound has been gaining in popularity after improvement in its technology.The images are clearer and the transducer heads are smaller.Ultrasound guidance is much cheaper and less time consuming compared with stereotactic techniques.An added advantage is its ability to be real time and thus able to monitor any haemorrhage and degree of success of an aspiration.

A further advancement in the use of ultrasound guidance is the use of a fixation device.Freehand needle biopsy is unsuccessful in an appreciable proportion of cases especially if the target aimed at is small.This has been more important since improved imaging techniques have led to early detection of smaller lesions.

In this phase of the project we have concentrated on the design and testing of a fixation device that can be used with the available ultrasound machine.

Our results indicate that the accuracy of the system is adequate for clinical use. Most of the intracranial lesions seen locally are larger than 1 cm and are typically 2.5 cm and above. The accuracy of the system has been proven to a minimum size of 1 cm.In the study by Borgstein et al(4) using the berger neurobiopsy device,no lesion biopsied was smaller than 2.5cm.

The site for a burrhole in relation to the lesion is important.A lesion located too far sideway from the burrhole will not be visible by ultrasound. This is more critical for a superficial lesion and also for a smaller burr hole.It has been suggested and we agree that a skin marker be placed during the pre biopsy CT for best placement of the burr hole.

The design of our prototype fixation device although adequate can be improved.First and foremost is the lack of suitable local engineering firms that can machine the instrument using a lighter material such as aluminium or durable plastic rather than steel which is too heavy. Secondly, there is a need to alter the design of joint "A" to make it more convenient to use.

In conclusion, we believe that after certain modifications as mentioned above the fixation device we have designed and tested is workable and can be used for intraoperative intracranial ultrasound guided aspiration and biopsy.We are ready to embark on the second phase of the project.

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4. Borgstein RL,Moxon RA,Hately W, et al.Preliminary experience with the Berger Neurobiopsy for ultrasound guided aspiration and biopsy of intracranial lesions. Clin Rad.(1991)44,98-103.

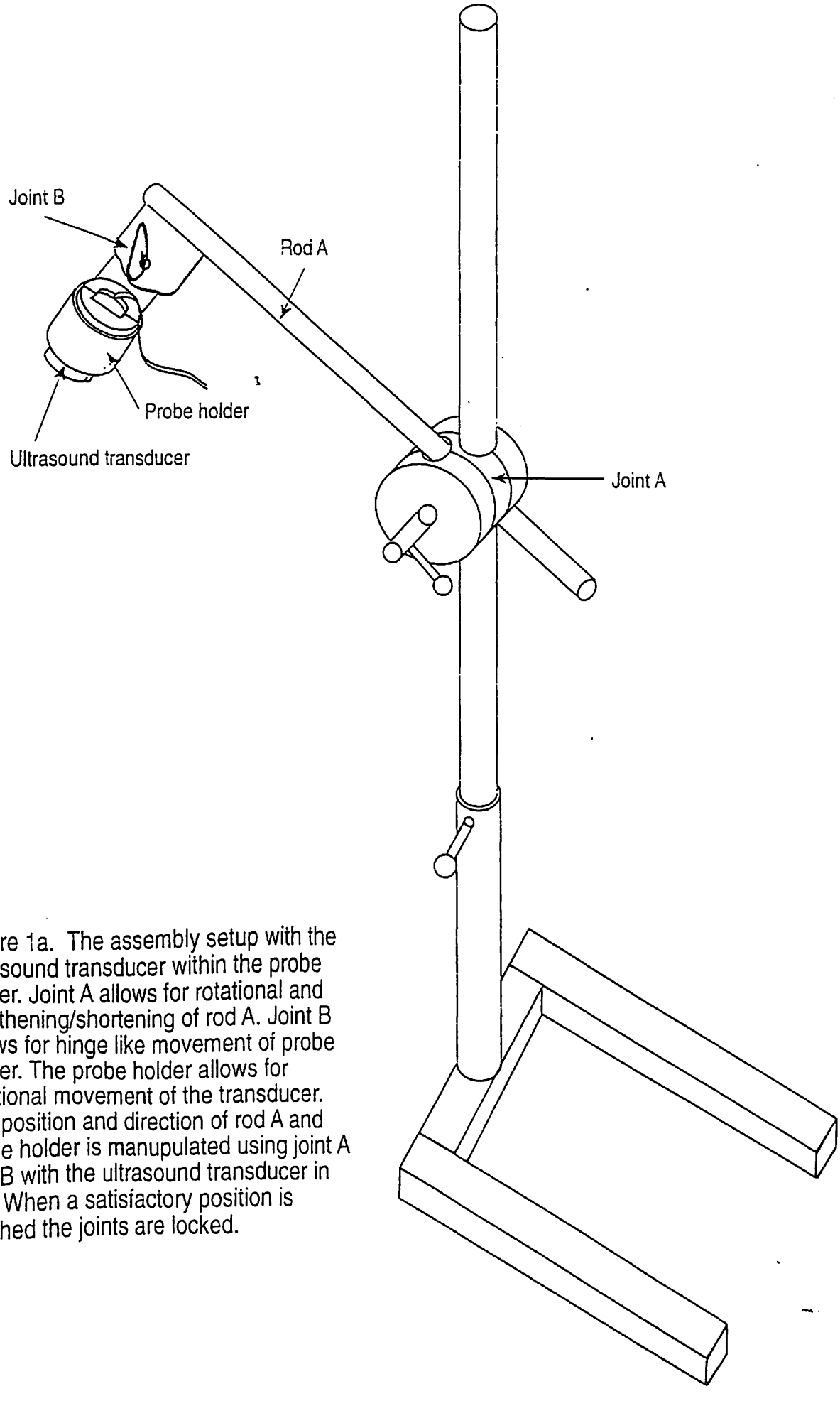


Figure 1a. The assembly setup with the ultrasound transducer within the probe holder. Joint A allows for rotational and lengthening/shortening of rod A. Joint B allows for hinge like movement of probe holder. The probe holder allows for rotational movement of the transducer. The position and direction of rod A and probe holder is manupulated using joint A and B with the ultrasound transducer in situ. When a satisfactory position is reached the joints are locked.

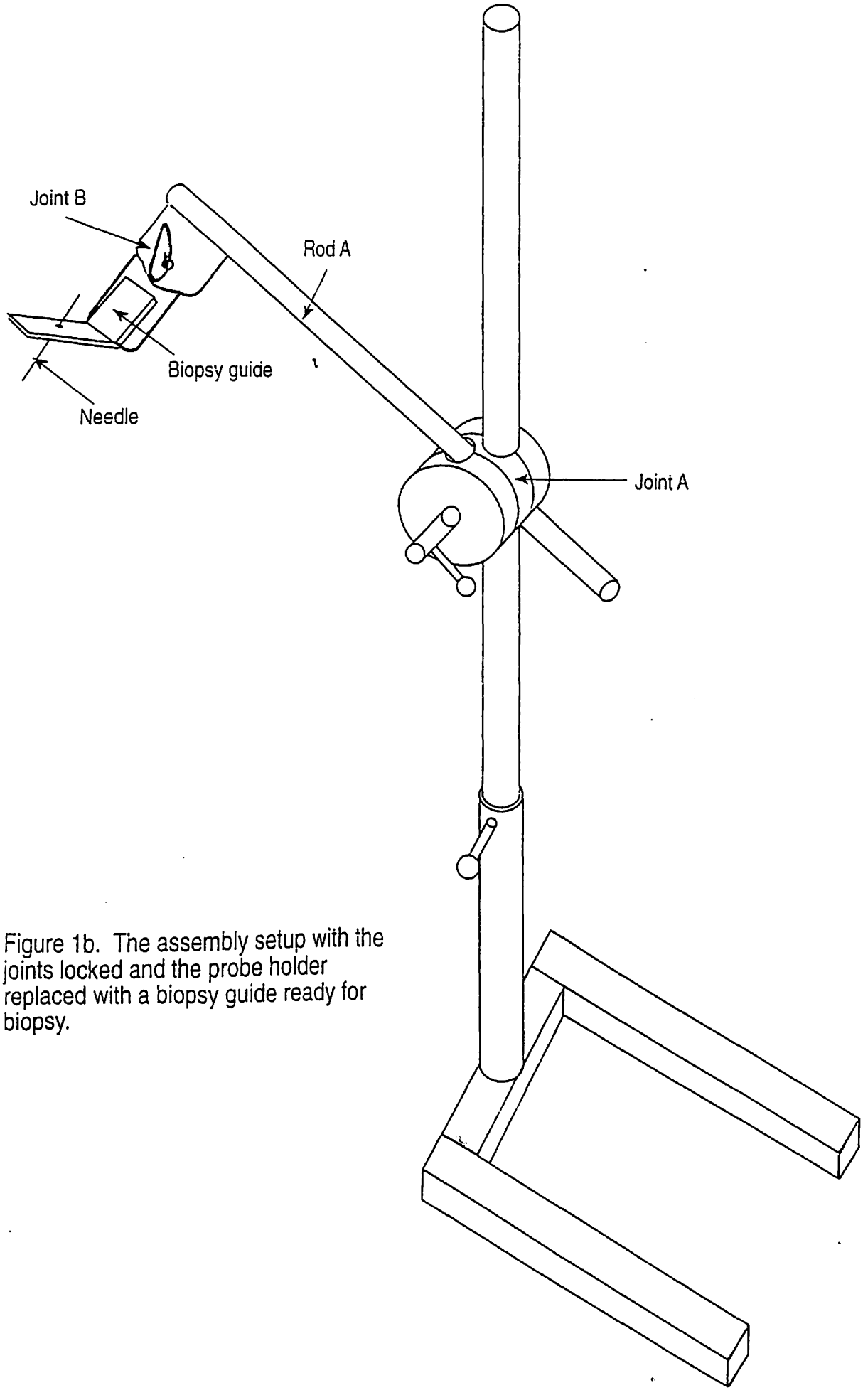


Figure 1b. The assembly setup with the joints locked and the probe holder replaced with a biopsy guide ready for biopsy.

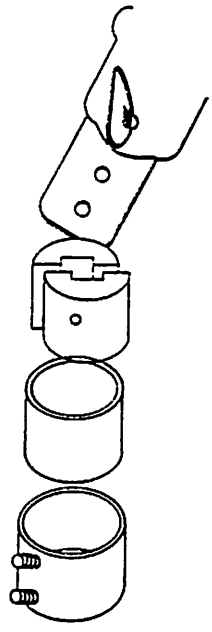


Figure 1c. Exploded view of probe holder which allows for rotational movement of ultrasound transducer. It is made of three cylinders.

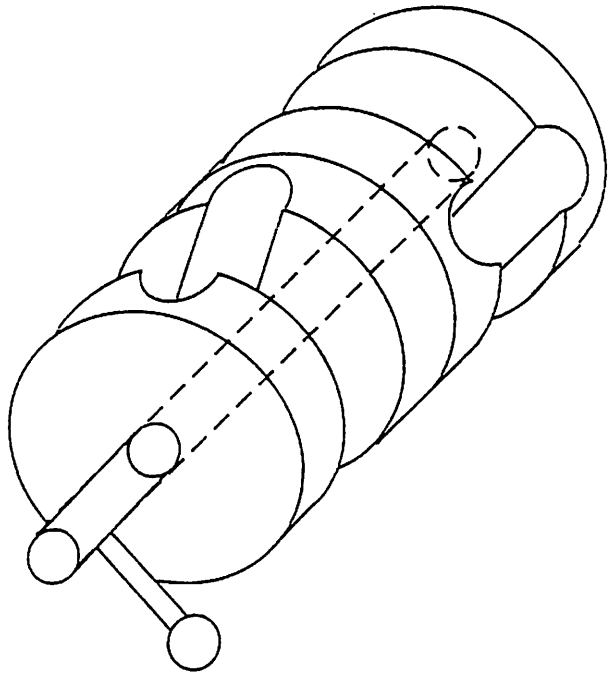
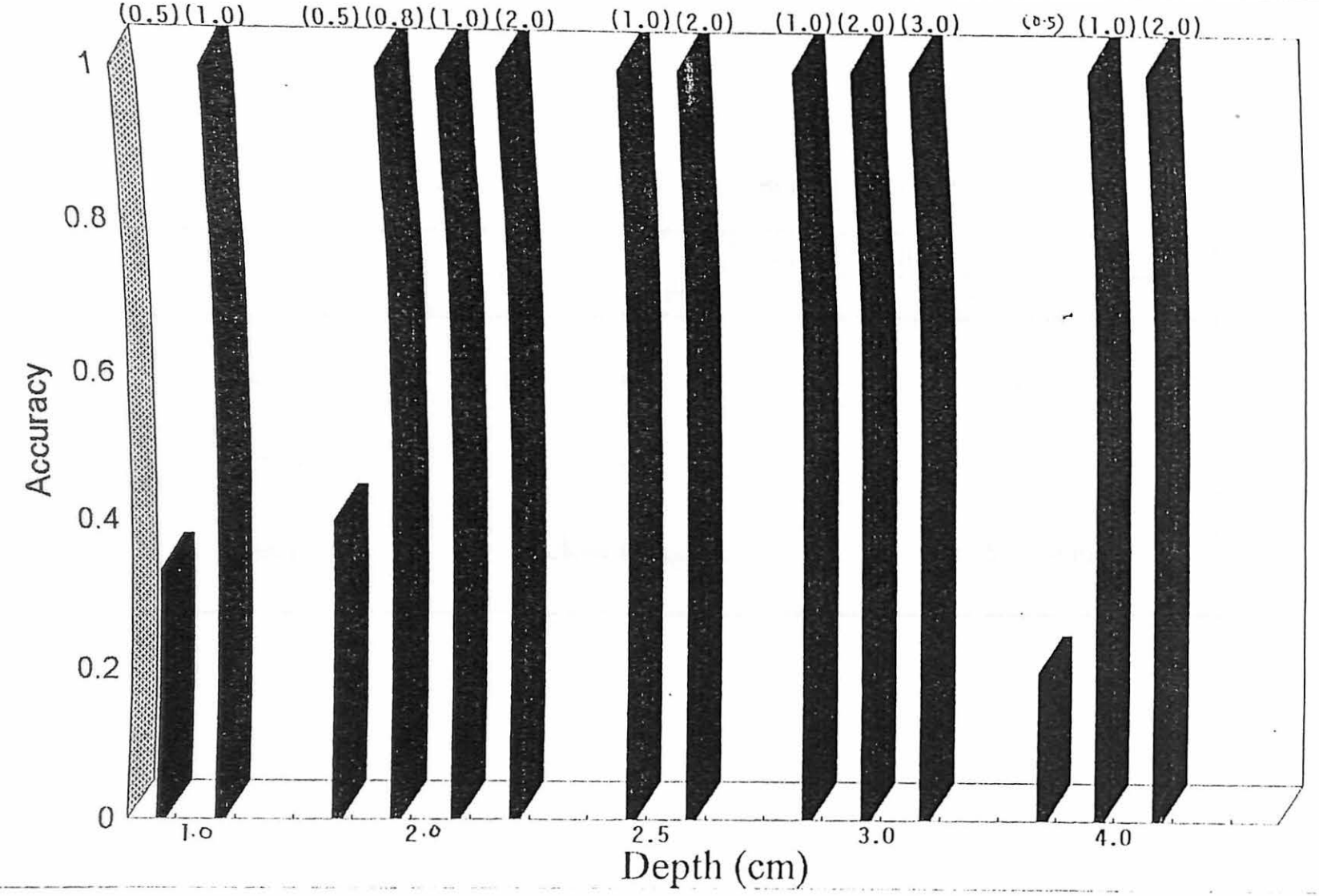


Figure 1d. Exploded view of joint A which allows for rotational and lengthening/shortening movement of rod A.

Fig 2: Relationship between depth and lesion size vs accuracy



epresent size of sample in cm

Table 1: Relation between size of "burr hole" and limit of lateral visibility

"Burr hole" size	Limit of Lateral Visibility	
	1.5 cm depth	3.0cm depth
3.0cm	3.5cm	4.0cm
1.5cm	1.5cm	2.0cm
1.0cm	unclear image	unclear image