

# MICROWAVE DIATHERMY

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## SUMMARY

An extensive literature survey is summarised. Experimentation consisted of irradiation of paraffin wax and human subjects with microwave of frequency 2 450 MHz. Results, conclusions and recommendations are briefly stated. A full reference list is given.

## INTRODUCTION

Microwave has been used therapeutically in physiotherapy departments since 1951 (Scott, 1968a), and is now used almost worldwide. Most large physiotherapy departments possess at least one microwave generator and there has been an even greater increase and acceptance of its use by private practitioners (Scott, 1968a). This increase in usage should have been accompanied by an increase in research done into the effects and usages of microwave. Instead, few articles have been published over the past years.

Enquiry has revealed that there exists a lack of knowledge amongst physiotherapists about the working of the machine, the effects of microwave on body tissues, the dosages to be prescribed and the danger if not properly administered.

Much of the literature appears to be in conflict and different theories have been formulated, most of which have never been proven conclusively.

Our study was confined to the therapeutic range of microwave diathermy, mainly that of 2 450 MHz.

The aims of this study were as follows:

- To review fully and report all available literature.
- To illustrate all points of confusion.
- To attempt to clarify by experimentation certain points:
  - the effective depth of penetration of microwave;
  - the effect of varying some of the determining factors of dosage;
  - the actual amount of heating occurring in the skin at therapeutic dosages.
- To assess the value of paraffin wax as a suitable biological tissue phantom for experimentation.

## LITERATURE SURVEY

From the available literature several points of interest were extracted, viz. the physical characteristics of microwave, the production of microwave by diathermy machines, the types of apparatus commonly used, the effect of microwave on body tissues, the physiological results of these effects, the therapeutic uses and indications for the use of microwave diathermy, contra-indications to the use of microwave, method of microwave application, advantages and disadvantages of microwave diathermy, dosage estimation and measurement and the effects of excessive dosages.

Several points of interest worthy of note emerged from this part of the study:

- It is evident that the actual percentage of microwave radiation which is reflected at the skin surface (and at other interfaces in the tissue) has not been established as yet although several values have been suggested (McLees and Finch, 1973; Michaelson, 1971; Scowcroft *et al.*, 1977).

## OPSOMMING

'n Uitgebreide oorsig van literatuur word opgesom. Eksperimentasie het bestaan uit irradiasie van parafienwas en proefpersone met mikrogolf met 'n frekwensie van 2 450 MHz. Resultate, gevolgtrekkings en aanbevelings word kortliks genoem. 'n Volledige lys van verwysings word gegee.

- The depth of penetration of microwave is also not known — the standard quoted depth of 3 cm being theoretical and in fact now thought to be incorrect. The depth of penetration is affected by several variables, for example, the thickness of the skin, the dielectric constant of the tissues, and the number of interfaces within the tissues (microwave being reflected at interfaces) (Scott, 1968a; Scott, 1968b; Hollander, 1968; Scott, 1975; Lehman *et al.*, 1962; Krusen *et al.*, 1971; de Lateur *et al.*, 1970).
- Any physiological effects of microwave are as a result of heating of the tissues, these effects being an increased metabolism of the irradiated tissues, an increase in blood flow to the area, muscle relaxation and increased activity of sweat glands (Scott, 1968a; McLees and Finch, 1973; Vernier *et al.*, 1978; Fench *et al.*, 1949; Krusen, 1950; Hovind and Nielsen, 1974).
- It appears unlikely from studies done that microwave can have any effect on tissues other than those of the skin and subcutaneous tissues as it is doubtful that heating occurs at any depth greater than 3 cm from the body surface.
- Although it is reported that microwave has been successful in treating a number of conditions there is very little conclusive evidence to support these claims and all of these conditions may be successfully treated using other modalities (Scott, 1968a; Scott, 1968b; Scott, 1975; Krusen, 1950; Lehman *et al.*, 1939; Lehman *et al.*, 1954; Instruction Manual).
- There are several contra-indications and conditions where care must be taken concerning the use of microwave diathermy. These include metal in the field, treatment of the eye (which may cause the development of lenticular opacities), poor circulation both physiological (i.e. areas having poor circulation e.g. testes) and pathological (e.g. circulatory diseases), bony prominences (due to the reflection of the electromagnetic waves of microwave), water or moisture in the field, defective sensation, cardiac pacemakers, pregnancy and menstruation, tuberculous or oedematous areas, malignancy or areas of haemorrhage, areas which have received deep X-ray therapy in the last six months (McLees and Finch, 1973; Michaelson, 1971; Scowcroft *et al.*, 1977; Scott, 1968b; Scott, 1975; Krusen *et al.*, 1971; Feuch *et al.*, 1949; Krusen, 1950; Richardson, 1955; Kantor and Witters, 1976).
- Excessive dosage of microwave results in severe soft tissue burns and there is thought to be some detrimental effect on bone. It may also cause damage to the testes and eyes if excessive dosages are given (Michaelson, 1971; Scowcroft *et al.*, 1977; Scott, 1968b; Krusen *et al.*, 1971; Krusen, 1950).

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- Microwave is thought to be a convenient modality of treatment as it is easy to apply and there are no tuning or field problems. The duration of treatment required is said to be, on average, approximately half that of short-wave diathermy. However, from the literature it is evident that the effective depth of penetration limits its use so as to make it fairly disadvantageous (Scott, 1968b; Hollander, 1968).
- Several guidelines for application were stated. These followed very closely the precautions which should be kept in mind when using short-wave diathermy. In addition the microwave beam should never be directed at the patient's eyes or at anyone else nearby (Scowcroft *et al.*, 1977; Scott, 1977; Instructional Manual).
- The estimation of dosage is one of the most controversial points in the literature and there is uncertainty over whether an accurate measurement of dosage (using the wattage output meter) should be employed or whether, as with short-wave diathermy, the physiotherapist should rely on the patient's sensation in order to estimate the dosage. It is said that the minimum dosage to produce any heating is an exposure of 0,02 W/cm<sup>2</sup>. Exposure to 0,1 W/cm<sup>2</sup> for periods of an hour or more can produce pathological changes in tissue. Treatment times usually vary between ten and thirty minutes. The distance of the applicator makes very little difference to the dosage. As with short-wave diathermy, mild thermal doses are given in acute conditions and thermal doses in chronic conditions. It is also felt that the dosage should be greatly reduced for whole body exposures (McLees and Finch, 1973; Scott, 1968b; Lehmann *et al.*, 1962; Krusen *et al.*, 1971; Instructional Manual; Heath, 1974; Brown and Johnson, 1975).

## EXPERIMENTATION

The experimental part of this study was divided into two sections.

- Microwave irradiation of paraffin wax.
- Microwave irradiation of human subjects.

For both of the above studies the Microtron 200 Microwave Diathermy unit with a frequency of 2.450 MHz was used. The oval field applicator, which gives an even field, was used.

### Paraffin Wax

An experimental rig consisting of a perspex frame which held chromel-alumel thermocouple wires at predetermined distances apart was immersed in the paraffin wax which was then allowed to solidify. The wires were on the surface, 1 mm, 5 mm, 10 mm, 20 mm, 30 mm, 40 mm and 100 mm below the surface. The thermocouple wires were attached to the recording apparatus which comprised a digital volt meter, electronic ice reference junction and multiway switch. This rig enabled us to measure temperature changes at precise depths of wax. After calibration the paraffin wax was irradiated with the applicator at varying distances from the surface, at different intensities of irradiation, and recordings were taken at five minute intervals during the entire exposure. In this way the effects of intensity, distance of applicator and duration of exposure could be estimated.

### Human Subjects

Similar chromel-alumel thermocouples were inserted into the extensor surfaces of the forearms of the human subjects approximately 70 mm from the distal ante-

cubital crease to a depth of 2,5 mm below the skin surface. The human subjects were then irradiated with microwave at the therapeutic dosage of 100 W for 20 minutes at a distance of 15,0 cm.

## RESULTS

Several interesting phenomena emerged from the experimental part of the study:

- The greatest increase in temperature occurred in the first five minutes of exposure in both the wax and human subject trials. This increase in temperature continued (at a slower rate) for the next fifteen minutes in the wax. The temperatures recorded during the human subject trials, however, showed a decrease in temperature after the initial increase and in two of the subjects the temperature recorded at the end of exposure were in fact lower than at the start. This is thought to be as a result of a compensatory increase in subcutaneous blood flow in response to the initial temperature increase, resulting in the transport of heat away from the area via the venous capillary network (Stoll, 1960).
- From the above it is also evident that no transfer of heat by conduction to deeper layers can occur as a temperature gradient does not exist. It is therefore unlikely that muscle tissue can be heated in this manner.
- It is thought, therefore, that any therapeutic results which have been reported may have been as a result of the increased blood flow to the tissues.
- Temperature increase of the thermocouples in the wax was proportional to increases in intensity of irradiation thus confirming that the output of the machine is an important factor when considering dosage whereas alterations of the distance did not affect temperature changes.
- It was evident that paraffin wax, although it exhibited several interesting pertinent phenomena, is not a suitable biological tissue phantom for further studies. There are several incompatible differences (apart from the obvious lack of blood supply) between paraffin wax and body tissue. Absorption of microwave is largely dependent on water content (McLees and Finch, 1973; Michaelson, 1971) and since wax has no water content, the microwave is transmitted and caused an almost equal rise in temperature in all thermocouples. Microwave is also reflected at interfaces and as wax contains no interfaces the results are altered.

## CONCLUSIONS

Several conclusions were drawn from this research:

- There is still much contradiction in the literature which requires clarification before microwave diathermy can be used with confidence.
- The effective depth of penetration of microwave is as yet unknown.
- Although microwave is said to be an effective and useful treatment, there is no conclusive evidence of this.
- Microwave diathermy appears to produce no appreciable temperature increase in subcutaneous tissue at therapeutic dosage.
- The wattage output of the machine directly affects the heating occurring whereas the distance of the applicator does not.
- Paraffin wax is not a suitable biological tissue phantom on which to conduct further studies.

## RECOMMENDATIONS

It is recommended that further research be carried out into several aspects of microwave diathermy:

- The effective depth of penetration.
- The amount of heating occurring at all depths in human skin.
- The actual amount of reflection which occurs at the surface of the body.
- The actual dosage which should be applied and the installation of a uniform system of estimation.
- An attempt to find a suitable biological tissue phantom on which to perform these investigations.

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# WCPT NEWSLETTER

## REGIONAL SEMINARS

The first regional seminar organised by WCPT was held in Geneva in October 1980 and dealt with aspects of EMG, Statistics and Writing for Scientific Publications. A video-film introducing EMG Kinesiology is available in 16mm (either U-matic or V.C.R. system) from Mr. Yves Blanc, RPT, Laboratoire de Myocine-sigraphie, Hôpital Cantonal Universitaire, 1211 Geneva 4, Switzerland at cost of return postage. An expanded text, with introduction by Prof. J. V. Bas-majian available from WCPT Headquarters, 16/19 Eastcastle Street, London WIN 7PA on provision of a large self addressed envelope plus 2 international postal reply coupons.

The second regional seminar will be held in Geneva in October 1981 and will deal with the physiology, evaluation, psychological aspects and treatment of pain by means of TENS amongst others.

## WCPT NEWS

The Zambia Society of Physiotherapy has been granted provisional approval. The Executive Committee met in Bangkok in January.

## ASIAN CONFEDERATION FOR PHYSICAL THERAPY

Thailand hosted the first Assembly of the above at the same time as the meeting of the Executive Committee. Associations from Indonesia, Japan, Korea,

Philippines, Republic of China and Thailand participated.

## AUSTRALIA

The APA is marking its 75th anniversary with an Austral-Asian Congress in Singapore from 31 May - 6 June 1981. A week-long intensive course in acupuncture will precede the Congress, which will deal with manual therapy, neurology and general sessions. Details from Mr. M. Corfee, APA Congress '81 Secretariat, 1st Floor, 33 Park Street, South Melbourne, Victoria 3205, Australia.

## EGYPT

The first national Congress of E.P.T.A. was held in May 1980 in Cairo, as well as the Assembly of the African Physiotherapy Organisation with participation from Egypt, Canada, Ethiopia, Ghana, Nigeria, U.S.A. and Zambia.

## FRANCE

A scientific data base of computer based information on physical therapy, physical medicine and rehabilitation from physiotherapy journals from Canada, Netherlands, South Africa, Sweden and U.S.A. as well as monographs, doctoral theses and other documents has been established. The price of a question is 150 French francs (US \$35, £16, Sw.kr. 150) available from BLD0C, B.P.12 60260, Lamorlaye, France.