Ultrasound Treatment may not be a Contraindication for Joint Arthroplasty

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ABSTRACT

Introduction: Ultrasound (US) is a highly used clinical modality for a variety of pathologies. Historically there have been several contraindications for the use of US but there is a paucity of evidence regarding the use of US in the area of a joint arthroplasty. The purpose of this study was to examine the effects of therapeutic US on the methyl methacrylate (MMA) used to secure the prosthesis of a hip arthroplasty in a pig.

Procedure: A hip prosthesis was sized and surgically implanted in a freshly slaughtered pig. The pig underwent a 16-slice baseline CT-scan after the surgical procedure. Forty US treatments were rendered over the lateral aspect of the hip with an Omni-Sound * 5-cm² transducer at a 1-MHz frequency at 1.5 W/cm² using overlapping circles in a 3-ERA area for 10 minutes. Two indwelling thermisters (Physiotemp) were used to monitor tissue temperature. After each set of 10 US treatments, a repeat CT scan was performed. Results: Three orthopedic surgeons were blinded to the sequence of the CT-scans. They analyzed the scans in the anterior-posterior, lateral, and axial views for interface widening by Gruen zones. There was 100% agreement that there was no evidence of MMA fragmentation. All radiolucent zones were less then 1 mm in width and there was no significant difference in the interface width between the CT scans (p = 0.21, 0.42, 0.57). Conclusions: Based on the results of this study, it does not appear that US had a deleterious effect on the MMA used to secure the hip prosthesis. Although the parameters used were within therapeutic range and mild tissue heating was achieved, the number of treatments was extreme. This was a conscious decision to be assured that if deleterious effects were to occur, the parameters used would provoke them. Despite this being a single-subject design, the researchers believe this methodology is a reasonable approach to begin to make clinical decisions about US and arthroplasties. Of course, clinicians should exercise caution when rendering US in the area of an arthroplasty, however, it appears reasonable to use this modality for soft tissue heating and healing in the general area of an arthroplasty.

Key Words: ultrasound contraindications, orthopedic implants, methyl methacrylate

INTRODUCTION

Ultrasound (US) is a highly used clinical modality in physical therapy with both thermal and mechanical effects. Thermal effects help to increase blood flow, tissue metabolism, enzymatic activity, and oxygen uptake. Whereas, mechanical effects include increased cell membrane permeability, histamine release, macrophage and fibroblast activity, intracellular calcium, and protein synthesis. All of these processes are essential to tissue healing. Hence, US is appropriate for the treatment of soft tissue pathology such as muscle strains, ligament sprains, tendonitis, and bursitis, to name a few. However, there are some contraindications to the use of US. Contraindications such as the presence of a cardiac pacemaker, lack of sensation, and malignant growths has documented deleterious effects. But, other contraindications for US have been perpetuated in the literature for many decades because of the challenges of investigating them. One such contraindication involves the use of US in the area of a joint arthroplasty. This is a situation that has created challenges to study because of the ethical issue of placing a person at risk for unknown consequences. The fear of using US on joint replacements has been out of concern for the potential compromise to the integrity of the material used to cement the prosthesis in place. The purpose of this study is to examine the effects of 1-MHz US on the joint replacement cement (methyl methacrylate) to secure a hip replacement in a pig.

PROCEDURE

A self-centering universal hip prosthesis (DePuy Inc, Warsaw, Ind) was sized (39 mm OD femoral metal cup; 28 mm ID poly insert) and surgically implanted via a posterior approach by a licensed orthopedic surgeon (JJN) into a freshly slaughtered pig (Kolb Brother’s Butcher, Spring City, Pa). Methyl methacrylate (MMA) was used to cement the prosthesis in place. Two, 4-cm, 29-gauge thermisters (Physiotemp Instruments Inc, Clifton, NJ) were inserted into the soft tissue of the surgical hip to monitor temperature changes throughout the US treatment. Both thermisters were placed in the path of the propagated US beam. One thermister was superficial to the shaft of the prosthesis at a depth of 1.5 cm and one was adjacent to the shaft of the prosthesis at a depth of 2.5 cm. A baseline 16-slice CT-scan was performed to identify the presence of radiolucent zones.

Forty consecutive US treatments were rendered with an OmniSound (Accelerated Care Plus, Topeka, Kan) 5-cm² transducer (4.9-cm² effective radiating area) at a 1-MHz frequency to target deeper tissue. An intensity of 1.5 w/cm² was delivered using overlapping circles in an area that was three times the transducer effective radiating area. The beam non-uniformity ratio identified by the manufacturer was 2:1. The transducer was moved at a rate of 3-4 cm/sec. Each treatment was 10 minutes in duration over the lateral aspect of the hip. The parameters implemented were based on previous research and clinical experiences. All treatments were performed by the same licensed physical therapist (DTG). Tissue temperature was recorded via both thermisters every 30 seconds for the duration of each US treatment. Tissue temperature was allowed to return to baseline between US...
treatments. After each set of 10 US treatments, a repeat 16-slice CT scan was immediately performed. Data collection was a continuous process with the time from slaughter to completion of all 40 US treatments being 35 hours.

RESULTS

Three orthopaedic surgeons were blinded to the sequence of the CT scans. They analyzed the scans in the anterior-posterior, lateral, and axial views for interface widening by Gruen’s Zones (Figure 1 and 2).13-16 There was 100% agreement that there was no evidence of MMA fragmentation. All radiolucent zones were less than 1 mm in width and an analysis of variance revealed that there was no significant difference in the interface width between the CT scans (p = 0.21, 0.42, 0.57) for each surgeon. Tissue temperature increased an average of 1°C per treatment at each thermistor site.

CONCLUSIONS

As previously stated, therapeutic US (1 and 3 MHz) is used for both thermal and mechanical effects on soft tissue. Lower frequency US (46.5 kHz) has been used to remove plaque in dentistry, cataracts in ophthalmology, and cement securing orthopaedic implants.7-9 Thus, there is concern that many of the contraindications identified, the sources identified from 9 to 36 contraindications across 85 conditions. Although arthroplasty was one of the many contraindications identified, the sources ranged from 20% to 95% agreement across the various pathologies. Unfortunately, numerous sources did not cite a reference for their stated contraindications. It appears that many of the contraindications identified were simply perpetuated over time without a basis of scientific support. For many of the conditions identified, it would be unethical to subject an individual to the potential risks associated with the administration of ultrasound, ie, pregnancy, growth plates, and orthopaedic appliances. Thus, no research has been published for many of the conditions.

Based on the results of this study, it does not appear that US had a deleterious effect on the MMA used to secure the hip prosthesis. Although the parameters used were within therapeutic range and mild tissue heating was achieved at the depth of the prosthesis, the number of treatments was extreme. This was a conscious decision to be assured that if deleterious effects were to occur, the parameters used would provoke them. Despite this being a single-subject/swine design, the researchers believe this methodology is a reasonable approach to begin to make clinical decisions about the effects of US on arthroplasties. Although there is no therapeutic rationale for the direct application of US to a prosthetic implant, there are benefits to treating the surrounding soft tissue. Range of motion limitations resulting from musculature tension or shortening has been reported to respond well to thermal effects.21-25 Of course, clinicians should always exercise caution when rendering US to avoid extreme heating (> 4°C). However, it appears reasonable to use this modality for soft tissue heating and healing in the general area of an arthroplasty without causing harm to the implant. Future research could be directed at delivering the US at higher intensities and/or using US units with greater beam non-uniformity ratios (BNR) to challenge the magnitude of tissue heating.26 The increase in intensity and BNR may enhance both the thermal and mechanical effects to the underlying tissue.

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REFERENCES


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**Figure 1.** Gruen’s Zones for the femoral component of a hip arthroplasty. Reprinted with permission from gentili.net. © Amilcare Gentili, MD.

**Figure 2.** Gruen’s Zones for the acetabular component of a hip arthroplasty. Reprinted with permission from gentili.net. © Amilcare Gentili, MD.

Outstanding Peer Reviewed Journal Award

Our *Journal of Orthopaedic and Sports Physical Therapy* (JOSPT) received the Outstanding Peer Reviewed Journal award at Annual Conference this past June. In the photo APTA President Ben Massey presented the award to Mike Cibulka, Orthopaedic Section President, who accepted the component award.