Introduction: The use of laser technology in medicine has progressed rapidly over the past 40 years and lasers are widely used in surgical treatment today. Several features have contributed to the popularity of the laser as a surgical tool. Because of the cauterizing effect of the laser, bleeding can be confined to the local tissue area only. When used in the surgery of soft tissues, only a thin (200 to 300 micron) layer of coagulation can be confined to the local tissue area only. When used in the surgery of soft tissues, only a thin (200 to 300 micron) layer of coagulation damage is produced, thus promoting earlier healing and less risk of infection. Operating time could be reduced thus, lowering the chance of infection. Lasers can be used without direct physical contact, thereby further reducing the chance of wound contamination. The objective of this investigation was to evaluate the efficacy of CO2 laser in drilling bone and compare it to that of a conventional drill.

Materials and Methods: Eight pairs of fresh (previously frozen) rabbit humeri were used. The specimens were divided into two groups alternating left and right with one group for conventional drilling and the other for drilling with the laser. The laser group was divided randomly into an additional two groups one for continuous wave (cw) and the other for rapid super pulse (rsp mode). The laser (Zeiss Model OPMILAS CO2 50) had wavelength of 10.6 microns and a variable continuous wave power of 0.25 to 50 W. A hole approximately 1 mm in diameter was drilled through the cortex to the medullary canal. The continuous wave mode was set at a power of 10 W with a single pulse duration of 1 second. The same was done for the rapid super pulse mode except a power of 5 W was used with a repetition rate of 200 pulses per second. The diameter of the cutting beam was determined to be approximately 1 mm, therefore, a 1 mm drill bit was used. During the drilling of some of the specimens from each of the groups the temperature at a location near the drill site was measured with a portable temperature measuring device (Bailey model BAT-12 with a Type 1 thermocouple probe). Subsequent to drilling, the bone specimens were mechanically tested using a four point bending test. From these test, the mechanical properties of bone were calculated. A group of rabbit humeri which were exposed to the same methods as the others except that they were not drilled (intact) were also mechanically tested serving as a second control group for additional comparison.

Results: Upon gross observation, the continuous wave mode of the CO2 laser appeared to create a defect with three visible zones being a central empty zone (the hole), the outer zone of whiteness surrounding the hole, and a zone consisting of a fine black line at the perimeter of the second zone. These three zones corresponded to the zones of vaporization, subvaporization, and the zone of carbonization. The rapid super pulsed mode displayed the same pattern except that the zone of carbonization appeared slightly thinner and the zone of vaporization was more pronounced and defined. The rapid super pulsed laser resulted in a lower temperature than the continuous mode. Also, the rapid super pulsed mode only required 2 seconds to penetrate the cortex, yet the continuous wave mode required 2 to 3 seconds. The mean failure stress values for the cw laser, rsp laser, and the surgically drilled bones were 88.08 N/mm2, 94.55 N/mm2, and 118 N/mm2 respectively. Although these differences were not statistically significant (p<0.05) the differences represented a reduction of 20% in strength for the laser compared to the surgical drill. The continuous wave and rapid super pulsed CO2 laser readily drilled the rabbit cortex and produced lesions of less than 3 mm in diameter (diameter of all three zones). The continuous wave laser did drill the bone with a power setting of 5 W, yet it required much longer time and did not drill the hole as satisfactorily as it did at 10 W. Since the continuous wave drilled the bone more easily and satisfactorily at 10 W this was the power used. In general, the rapid super pulsed laser drilled the hole in a shorter time, at a lower temperature, and with less energy required and possible less damage. This suggest that although both modes of the CO2 laser drilled through the cortex easily, the rapid super pulse was more efficient than the continuous wave mode. All of the specimens broke through the defect (hole) which means that the bending test data was an accurate indicator of the effect of the hole.

Discussion: It should be noted that all of the specimens were drilled at room temperature and no attempt was made to reduce the thermal damage effects of either the laser or the drill. It is possible that by application of some temperature reduction technique such as irrigation by chilled water, the thermal damage effect of the laser could be reduced. The laser could reach areas that the drill could not without more invasive measures, and the risk of infection and bleeding could be reduced. Therefore, although the laser reduces the strength of the bone compared to the drill, it does have a potential future role in hard tissue surgery.

Acknowledgements: The technical help of Mr G.R. Williams and Dr. K.K. Sadashivan is greatly acknowledged.