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The Role of Water Jet Machining in Modern Surgery

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Description

Water jet machining is being utilized more and more for tissue dissection, ablation, and removal during medical operations, which mostly include tissue cutting. This is because it causes the least amount of heat damage, allows for tissue-selective separation, and minimizes blood loss. In terms of tissue types, process characteristics, tissue-water jet interaction mechanisms, tool solutions, and the development and classification of medical water jets, this paper reviews relevant studies and techniques for water jet machining in surgeries. It also highlights current research trends in hard tissue cutting and soft tissue dissection. The historical evolution and categorization of medical waterjet processes are covered first in the review. The waterjet processing of soft and hard tissues is then covered, covering topics such as tool design and applications, process features, cutting and dissection mechanisms, and tissue structures and properties. Then, waterjet solution techniques pertaining to biomimetic models, tissue properties, interactions between the tissue, process, and tool, as well as waterjet media and devices, are investigated. The analysis concludes by highlighting research gaps, obstacles, and upcoming advancements in waterjet procedures for several surgical applications, high cutting efficiency, and reduced trauma.

Cervical level

A catastrophic occurrence known as Spinal Cord Injury (SCI) results from trauma that mechanically damages the spinal cord. Significant brain function loss from SCI can have a severe negative impact on patients, their families, and society at large in terms of physical, psychological, and financial hardships. According to the study, the cervical level accounted for 88.1% of all neurological locations where traumatic SCI occurred. Seventy-seven percent of cases of cervical scoli include CSCI without bone injury; this combination most frequently happens in elderly patients following mild trauma, including falling on a flat surface. As previously described, we characterized CSCI without bone injury in this study as CSCI without evidence of spinal fracture or dislocation on computed tomography or plain radiography.

Although surgical reduction and stabilization of the spinal column are not necessary for this injury, spine surgeons have used varying therapeutic approaches for CSCI without bone injury. It was recently shown that, in cases of CSCI without bone fracture, the neurological outcomes from surgery and conservative treatment are similar. However, their study did not examine the possible impact of the timing of surgical treatment. Other earlier research has shown that traumatic SCI can be treated surgically as soon as possible to restore spinal cord blood flow and stop further damage. Moreover, early surgery for SCI is becoming increasingly recognized by spinal surgeons as a prudent and safe course of treatment. A multicenter worldwide prospective cohort study found that compared to late surgery, early surgery performed within 24 hours of CSCI was 2.8 times more likely to result in improvement of two or more grades on the American Spinal Injury Association (ASIA) impairment scale (AIS) six months later. Furthermore, found that patients who had early surgery within 24 hours of SCI had better neurological recovery and improved AIS grades at 1 year following surgery compared to those who had undergone late surgery in a pooled analysis of 1548 cases drawn from four independent, prospective, multicenter traumatic SCI data sources. Early surgery for traumatic SCI has been shown to have clinical benefits in the past; however, the therapeutic efficacy of this treatment for CSCI without bone injury in the elderly has not been thoroughly studied, and the results that have been found have generated debate.

Petroclival region

The removal of petroclival tumors or cerebellopontine angle tumors can be accomplished with extended exposure because to the common use of intradural petrous bone drilling. Drilling in this limited and deep location, however, puts neighboring neurovascular systems at danger. Therefore, the purpose of this study is to assess the effectiveness of PS as a non-rotating tool for selective bone cutting during CPA surgery. Analysis of the radiological and clinical data was done in the past. The intraoperative application and limitations of PS was assessed, along with the procedure's safety and efficacy. Meningioma or extra-axial metastases from the dura of the petroclival region have been successfully removed using piezosurgical petrous bone cutting. Compared to standard rotating drills, PS showed to be particularly useful in the deep and narrow CPA region, significantly reducing the surgeon's anxiety toward bone removal in close proximity to cranial nerves and arteries. There were no harms to neurovascular structures with PS use. In 100% of petrous bone tumors and 67% of petroclival bone tumors, gross complete resection was accomplished.