General Discussion and future perspectives

Surgery to the radial aspect of the wrist is known for its pain related complications.[1-3] These pain related complications cause severe problems in daily life of the patients[4,5]. There are many hypotheses to explain the susceptibility of the wrist to neuropathic pain[6,7].

A possible explanation could be, that undamaged peripheral nerve fibers are responsible for transmission of pain. It has been demonstrated, that the neurosomes of an injured nerve are populated by fibers from adjacent, uninjured undamaged nerves[8].These uninjured undamaged nerve fibers may change functionally as a consequence of a peripheral nerve lesion. Due to Wallerian degeneration of the distal segment of the injured nerve, undamaged nerve fibers are in close proximity of activated Schwann cells, macrophages, and other inflammatory cells, which secrete high levels of neurotrophic factors like NGF[9-10]. These neurotrophic factors are known to influence excitability, enhance sensory transmission, and/or induce ongoing activity in uninjured undamaged peripheral nerve fibers. Also, more proximal, in the Dorsal Root Ganglion (DRG), signaling from injured DRG cells could interfere with uninjured Dorsal Root Ganglions either directly or via non-neuronal cells. As a possible consequence, changes of excitability and/or ectopic activity in the cell bodies can occur.

It is possible, that if the one nerve is sectioned iatrogenically, the adjacent nerve might be responsible for the pain and vice versa.

In line with continuously changing insights in injury mechanisms and disease etiology, new anatomical research with new viewpoints is paramount. The use of new dissection techniques as well as new computer assisted surgical anatomy mapping and 3d mapping, can improve our understanding and make anatomy more visible for the end-user.

ANATOMY

The distal aspect of the wrist has been subject to anatomical research for decades, mainly because of the complex anatomy. Three main nerves are of interest: The Superficial branch of the radial nerve (SBRN), the Dorsal branch of the ulnar nerve (DBUN) and the Lateral antebrachial cutaneous nerve (LABCN).

In the dissection of the SBRN, recurring patterns could be identified. A number of studies[11-17] have identified these patterns before. However all but one study found 2 main patterns. Gupta Et al[15] was the first to describe a 3rd pattern in the course of the SBRN. In Gupta's paper he describes a low rate of occurrence of this 3rd pattern. In this thesis however the 3rd pattern was found in 25% of cases making it quite common and hence a quite relevant issue in the surgical approach of the wrist.

Specific recurring patterns as found in the course of the SBRN could not be found in the course of the DBUN. The course of the DBUN varies quite largely. Even between two arms of the same individual the pattern of the DBUN varies greatly. Many authors deny the existence of a communicating branch between the SBRN and the DBUN [17-19]. However, as observed in the present study, in 80% of cases the DBUN had a Radio-Ulnar Communicating Branch (RUCB). In other words, a branch that connects the DBUN with the SBRN.

The course of the LABCN closely follows that of the cephalic vein as described before by Beldner[13]. Also, a great amount of overlap could be seen between the LABCN and the SBRN. In 95% of cases the LABCN and the SBRN intersected and the distance between the two nerves was less than 10 mm in 81% of cases. In the images created in CASAM, a large amount of overlap could be observed. The close proximity of the two nerves could possibly lead to damage of not one but both nerves[20]. However, this does not explain why patients suffer from pain after denervation of the painful neuroma when no damage can be seen to the 2nd nerve. The close proximity of the nerves makes them susceptible to collateral sprouting and subsequent neuropathic pain.

SURGICAL TECHNIQUES

Surgical procedures in the forearm and hand have a high potential for iatrogenic nerve damage. Of all the nerves in the forearm, the SBRN is most at risk due to its anatomical course within the area in which most surgical procedures at the level of the distal radius are performed[21,22]. By using the newly developed mapping technique of the neural anatomy of the forearm, some surgical procedures were examined.

External fixation of distal radius fractures

External fixation is a widely used treatment option for distal radius fractures with a good functional outcome[23-25]. Less experienced surgeons can perform an external fixation procedure due to the fact that the technique is much simpler than volar plating.

Distal Pins

Measurements taken during this study and images created in CASAM, suggest a much lower density of nerve fibers across the third metacarpal compared to the second metacarpal. Placement of the pins in the third metacarpal is a safer alternative to the now widely used second metacarpal. Secondly, the 3rd metacarpal also allows for enough room not to damage the tendon.

Proximal pins

If we use the new insertion site, the proximal pins have to be moved accordingly. The space between the ECRB and the APL, proximal to the APL, offer good alignment, a good access to the bone and also no fibers of the LABCN and SBRN are present in this window.

First extensor compartment release

The surgical treatment of Quervains Disease (QD) is the treatment of choice after conservative measures have failed[26]. To operate safely in the area of the dorso-radial part of the distal radius and first metacarpal, the crossing and intertwining superficial branches of the radial nerve and the lateral cutaneous nerves (branches of the musculocutaneous nerve) immediately introduces a problem[1,27-30].

Four types of incisions are used to operate in this region: the transverse, the longitudinal, the 'lazy S' type incision and the specific angle technique. Each of which has its advantages and disadvantages and no best practice ('gold standard') could be found in literature. The incision techniques were analyzed by using the morphological data of the SBRN and the LABCN acquired from the 20 embalmed anatomical specimens used for this study. The data were then visualized by using CASAM.

Transverse incision technique

The transverse technique offers a good exposure while keeping the scar small and esthetically appropriate[21,32]. Also because the skin incision is perpendicular to the First Extensor Compartment (FEC), the retraction of the scar tissue is less likely to cause compression of the FEC and thus is less likely to cause a recurrence of the symptoms of QD. However, the transverse direction of the skin incision implicates a high risk of iatrogenic nerve damage.

Longitudinal incision technique

The longitudinal technique offers more exposure than the transverse incision[33-35] with a lower chance of iatrogenic nerve damage. However, this technique offers a suboptimal cosmetic result and because the scar is directly over the FEC, the retraction of scar tissue could cause compression of the FEC and recurrence of the symptoms of QD[36]. The available length for an incision placed between the first two branches of the SBRN is 43.5mm (SD 18,2). The nerve remains at risk due to its location over the FEC. Regarding nerve lesion, no 100% safety can be guaranteed but this technique is a better choice for less experienced surgeons.

Lazy-s incision technique

The 'lazy-S' technique has both advantages and disadvantages. The incision offers a good exposure and there is less chance of iatrogenic nerve damage when compared to the transverse incision[34,37]. However, the scar as a result of this incision is not as cosmetic as the transverse incision and the incision has a greater chance of iatrogenic damage to the nerve than the longitudinal incision. To spare the nerve, this technique is advised for the more experienced surgeon.

Specific angle technique

This technique offers a good exposure and minimizes the chance of iatrogenic damage to the nerve. It also offers a relatively cosmetically acceptable scar. However, the determination of the angle of the incision takes time and is labor-intensive.

All techniques described above for the treatment of Quervains disease have their own advantages and disadvantages. The choice of technique, depends on the priorities set by the surgeon. The main goal of this study was to identify the technique where iatrogenic damage to the SBRN is absent or minimal. The conclusion that can be made from the data is that despite the technique used, the retinaculum of the first dorsal compartment needs to be exposed by careful blunt dissection and divided under direct vision. Consequently, the surgeon can see that superficial nerves are not damaged. For beginning surgeons, the longitudinal incision offers good exposure and a smaller chance of iatrogenic nerve damage.

Wrist arthroscopy

During the last decade wrist arthroscopy is being used more and more as a therapeutic tool rather than a diagnostic tool and is also often being performed by less experienced surgeons. The standard portals used for diagnostic wrist arthroscopy show a low risk for iatrogenic damage and there is a low complication rate reported in literature[39-45]. The portals used for therapeutic wrist arthroscopy (3-4,4-5, 6U, 1R and 1U) however, are much more prone to iatrogenic damage, suggesting more complications could be reported in future.

During a wrist arthroscopy workshop 29 lesions were seen in 18 arms varying from vein and tendon damage to nerve transections and strangulations. Not all lesions observed during this arthroscopy workshop would lead to patient discomfort and complications in the short term, but surgeons must be vigilant for long term consequences.

Vein damage during surgery could impede visibility and thereby cause prolongation of surgery time. Furthermore, extensive damage to the superficial venous system can seriously impair wound healing leading to port site wound infections.

Nerve lesions were seen frequently in the repair of a TFCC lesion. These lesions could cause pain and long-term discomfort.

Tendon lesions, however infrequent in literature[46,47], could not only lead to short term consequences (e.g. ruptures) but could also lead to adhesions or late ruptures. When residents would take the time to dissect the specimen they worked on during the workshop, they could learn from their mistakes and improve their special awareness during wrist arthroscopy.

OVERALL CONCLUSIONS AND FUTURE PERSPECTIVES

The mechanism of the development of neuropathic pain in an area where nerves are as close together as has been proven in the study by Duraku[8], the close proximity between the LABCN and the SBRN coupled with the lesions seen due to surgery in the wrist could be the explanation why neuropathic pain in the wrist is more common than anywhere else in the body. It could also be an explanation why neuropathic pain remains hard to treat. Implementation and further study of the proposed new techniques could result in a decrease in short- and long term post-operative pain after wrist surgery.

Although many papers have been published on almost all possible anatomical structures, new techniques and equipment make it possible to find new variations, to better understand well known anatomical structures, or even cause us to rethink the course of an anatomical structure.

By using CASAM it was possible to show the neural anatomy of the forearm in a way never performed before. It can be used to analyze known surgical techniques in a new way. The new visualization of anatomical structures, presented in this thesis triggers students and surgeons to become more involved in safe and efficient surgery. More research has to be done on more specimen of the presented subjects and also on other anatomical structures to enlarge the anatomical CASAM database. With a larger database and further development of CASAM in the future, it could be possible to show the anatomical course of a structure at risk pre- and per-operatively in order to prevent damage and in turn reduce or even prevent surgical complications and hence improve surgical outcome for surgeons and, most important, for the patients.

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