Commission on the Future of Surgery

How will digital 3D imaging and planning shape the future of complex paediatric upper limb surgery?

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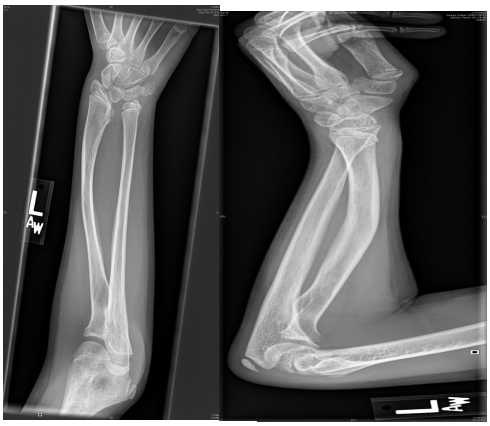
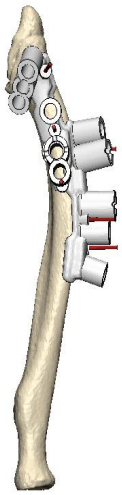
Congenital abnormalities and post-traumatic deformities in the paediatric population present unique surgical challenges where primary deformities may be further complicated by dynamic changes associated with growth and remodeling. Pediatric deformities are often multi-planar requiring the three dimensional correction of not only angular but more complex rotational deformities often at multiple levels. In these cases meticulous pre-operative planning is essential and is based upon optimal three dimensional imaging.

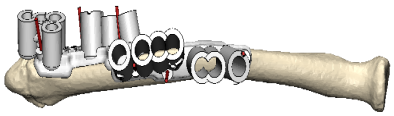
The applications of 3D printing within healthcare are growing rapidly in conjunction with other complementary technological advances. In surgery the primary uses of this emerging technology include patient-specific templates (custom cutting jigs which fit to the patients native anatomy and direct the saw blade in order to accurately replicate a pre-operatively tempted osteotomy) and patient-specific implants which negate the need to contour off the shelf implants to fit abnormal anatomy, an action which can weaken the device and lead to early failure. These advances represent the combined multidisciplinary efforts of radiologists, orthotists, surgeons and implant manufacturers. Patient-specific cutting jigs and implants offer a number of possible clinical benefits including the ability to perform more accurate and reproducible deformity corrections in a shorter period of time. Shorter operations can reduce the risks of swelling and secondary complications of long-term immobilization as well as reducing time spent under general anaesthesia with its intrinsic risks.

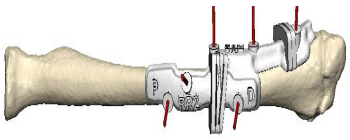
Our initial application of this emerging technology has focused on complex post traumatic and congenital deformity of the distal radius. The initial step involves the creation of a pre-operative 3D-simulation of the presenting deformity (Materialise, Leuven) based on specific CT sequencing. Following this a multidisciplinary process involving the clinical team and implant manufacturer occurs in order to discuss the surgical aims and objectives and identify an optimal correction. The final step of the pre-operative planning process involves the production of custom-made template guides for printing, sterilization and intra-operative use.

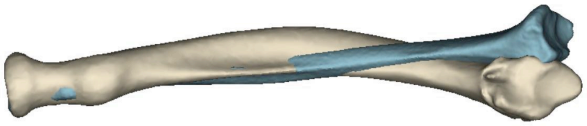
The following clinical case highlights the technical challenges posed by complex congenital deformity and the type of correction made possible by this emerging technology.











This teenage child had left dominant sided wrist pain - constant, worse on activity and didn't like the apparent cubitus valgus and clinically had reverse madelung's deformity. CT scanning showed a volcano-like depression in the lunate fossa with distortion that limited the extent to which normal anatomy could be restored.

The surgery involved a 2 level osteotomy + plating (at 90 degrees to each other) with a supracondylar osteotomy and ORIF. The obvious advantage was the ability to plan osteotomies accurately to limit risk of DRUJ problem from correction. Moreover, one was able to plan plates and whether to drill for locking or non-locking screws according to distance from planned osteotomy and therefore decrease the likelihood of causing a fracture.

Conclusion

There are clear advantages to digital 3D imaging and planning. There will be shorter operative times and decreasing anaesthetic risks. 3D printing is being used across many industries and costs will continue to go down as competition increases. The speed and production of 3D printing is also set to improve rapidly, and the future of 3D imaging and printing will certainly be used more seamlessly especially in the management of trauma.

The use of 3D computer imaging in our practice, highlights its role in planning, hardware selection, operative options and custom template printing. Management of complex upper limb deformities can be difficult, even for the experienced paediatric orthopaedic or plastic surgeon. Steps to simplify this process will facilitate adequate correction and reduce theatre times. Additional expense associated with this process will likely diminish with increasing use and availability.