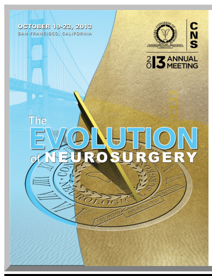

Analysis of Surgical Precision and Efficiency (Biometrics) in Resection of Intracranial Neoplasms

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Introduction:

Surgical biometrics is the process of examining and measuring the delivery of precision therapy in an efficient manner with the goal being to reduce the cost of patient morbidity and improve patient outcomes (precision) while optimizing the economics of resource expenditure and utilization (efficiency). Based on the experience with other surgical subspecialties, such as ophthalmology, we hypothesized that use of automated instrumentation would be more efficient than manual when feasible.

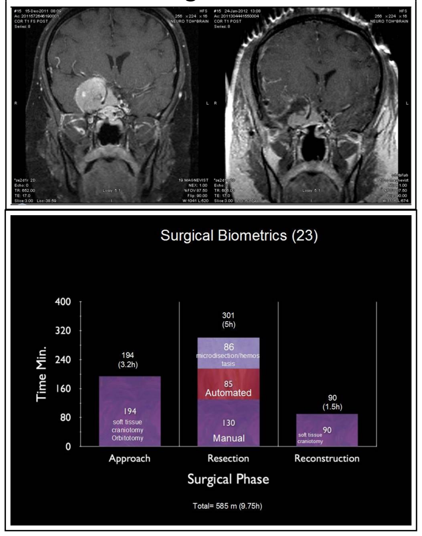
Methods:

A series of neurosurgical procedures including minimally invasive and conventional approaches were studied. Core components of each phase of surgery were examined for both precision and efficiency. These components were divided into the approach (exposure required to get from the external environment to the region of interest adjacent to the target), cytoreduction (removal of target tissue while preserving surrounding neurovascular tissue) and reconstruction (of both the external and internal corridor used in the approach). During each procedure a series of biometric data (time, automation, manual and component) were independently collected conterminously. The data was then converted using mathematical modeling into graphical representation and was subsequently analysed. Procedures were clustered based on general considerations to the degree possible; open vs. MIS (minimally invasive surgery), tumour type and comparison.

Results:

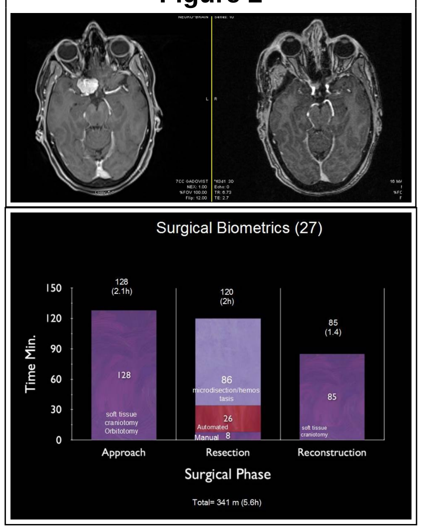
Case 23 had the highest slope between

Figure 1



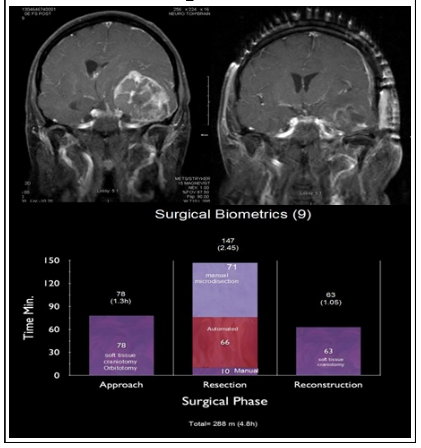
Pre-Op and Post-Op MRI images of resection of right sphenoid wing meningioma with biometrics of each component of surgery. Total time of resection: 9.75 hours.

Figure 2



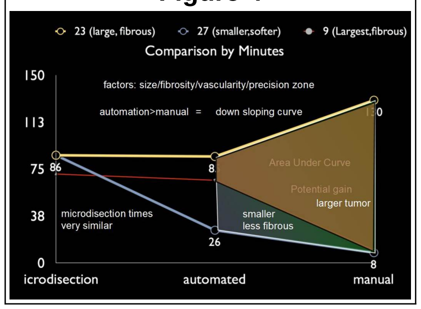
Pre-Op and Post-Op MRI images of resection of right sphenoid wing meningioma with biometric analysis of each surgical component.

Figure 3



Pre-Op and Post-Op MRI imaging of left temporal meningioma with biometric analysis of each phase of surgery.

Figure 4

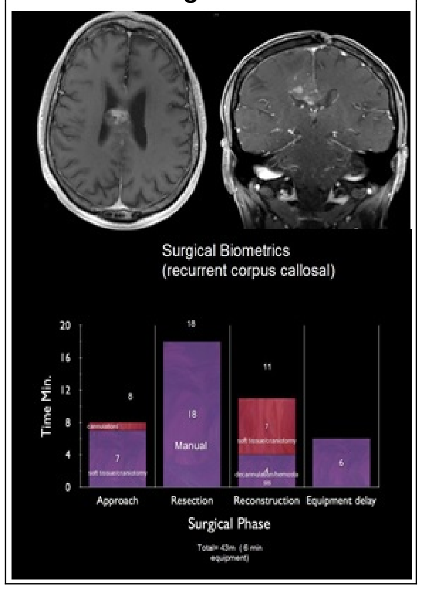


Analysis of the individual components of the cytoreduction phase of each of the previous meningioma resections.

the automated and manual phases, due to the large amount of time spent on manual resection. Case 27 took a lesser amount of time to resect. While this tumor was smaller in size, it was in the same precision zone as Case 23, requiring almost the same time for microdissection and hemostasis. However, much more time was spent performing automated resection compared to manual.

Case 9 was the largest tumor with the same precision zone (as can be seen with almost the same amount of time required for hemostasis and microdissection as the previous two cases). However, it required the least amount of total time to resect due to a much larger ratio of time spent on automated resection compared to manual (the slope between automated and manual is the steepest of all 3 cases).

Figure 5



Pre-Op and Post-Op MRI images of resection of recurrent corpus callosal Glioblastoma Multiforme (GBM) via MIS (brain port resection with the aid of DTI MR planning, not shown). Total time of procedure: 43 minutes.

Discussion:

All three meningiomas were resected using the same approach and hence the same reconstruction technique, and all had similar charactierisitcs except size. For example, they were all in the same precision zone (i.e. requiring delicate microdissection in order to preserve critical neurovascular structures).

In the conventional resection of these tumors, the approach and reconstruction were fairly similar in all of the cases with respect to the time taken. In addition, since they were all in the same precision zone, the microdissection component of the cytoreduction phase was not markedly different with respect to the amount of time taken in each case. Also, the only differing factor, the size of the tumor, was not the determining factor of efficiency. The difference was achieved by maximizing the degree of automation and reducing the use of manual resection for cytoreduction outside the precision zone. This can be seen as per the area under the curve in figure 4. The area (signifying gains in efficiency) was the greatest when the ratio of automated to manual resection was the highest. As all the patients in this study did very well post-op (no complications were seen), it was concluded that automation of cytoreduction outside of the precision zone allows for improved efficiency whilst maintaining patient safety.

Further analysis revealed that the approach and reconstruction stages in conventional open surgery are similar and it is difficult to improve upon their efficiency. However, the time needed for these stages can be greatly reduced if converted to MIS via brain port. The time needed for cannulation and decannulation is much less than craniotomy and orbitotomy, and hence leads to greater efficiency.

Conclusions:

Neurosurgical procedures, like other specialties, may be more efficient when automated instrumentation can be utilized. Furthermore, the use of MIS to improve the efficiency in the approach phase can lead to greater overall efficiency.