Motion Analysis as a Tool for the Evaluation of Oculoplastic Surgical Skill

Evaluation of Oculoplastic Surgical Skill

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Objective: To evaluate motion analysis as a discriminator of ophthalmic plastic surgical skill between surgeons of varying experience.

Methods: Thirty subjects were divided into 3 groups based on surgical experience: novice (<5 performed procedures; n=10), intermediate (5-100 procedures; n=10), and expert (>100 procedures; n=10). Detailed 3-dimensional motion data from surgeons performing 2 oculoplastic surgical tasks on a wet laboratory skills board were obtained using the Qualisys motion capture system. The first task was a deep 3-1-1 suture. The second was skin closure with a continuous suture. The main outcome measures were time, overall path length, and total number of movements. Kruskal-Wallis analysis was performed to evaluate statistical significance.

Results: Highly significant differences were found during the skin closure task between all groups for mean time ($P=0.002$), overall path length ($P=0.002$), and number of movements ($P=0.001$). For the deep stitch, highly significant differences were also found for time ($P<0.001$), path length ($P<0.001$), and number of movements ($P<0.001$).

Conclusions: Motion analysis, using this technology, was able to differentiate between surgeons of varying experience performing oculoplastic tasks, thus demonstrating construct validity. This technique may be useful in the objective quantitative measurement of oculoplastic skill, with potential applications for training and research.

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Training in ophthalmic surgery has been traditionally based on the apprenticeship system. With the innovation of video technology in the past few decades, recorded playback analysis with the supervising surgeon has become a popular method of training. However, this technique has a large interobserver variation and lacks quantifiable measures with which changes of surgical skill can be monitored over time.

The assessment of surgical technical skill has become more important in recent years and it has been shown that there is a significant correlation between objective measures of manual dexterity and surgical skill with the outcome of a procedure. Motion analysis, pioneered by Lord Ara Darzi, MD, KBE, is an emerging validated technique of surgical skill evaluation. To our knowledge, this method has not previously been applied to oculoplastic surgery.

The Qualisys motion capture instrument (Qualisys Medical AB, Gothenburg, Sweden) is a passive optoelectronic kinematic analysis system, most commonly used for the measurement of body motion, and has been validated and extensively used for gait analysis, motor control assessments, and upper limb function. Such technology is used for mocap (optical motion capture) in entertainment and virtual reality applications. We describe a new adaptation of this technology to ophthalmic plastic surgery and discuss future potential of this technique for surgical skill evaluation.

METHODS

MOTION ANALYSIS TECHNIQUE AND TECHNOLOGY

The Qualisys ProReflex 500 (Qualisys Medical AB) motion analyzer incorporates a multiple camera system arranged in a 360° fashion. Each motion capture camera unit

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PARTICIPANTS

Thirty subjects were divided into 3 groups (n = 10 each) based on surgical experience: novice (< 5 performed procedures), intermediate (5-100 performed procedures), and expert (>100 performed procedures). All subjects were given standardized instruction prior to the tasks, and an independent expert observer was present to ensure correct task completion in all cases.

SIMULATED SURGICAL TASKS

The first task was the insertion of a deep 3-1-1 suture using 6-0 polyglactin 910 (Vicryl; Ethicon, Somerville, New Jersey). It had to be placed around a metallic hook surrounded by a plastic cylinder (Figure, A). The suture needle was passed through the hook and then tied to the metallic frame (rim) with 3 throws on the first knot with 2 subsequent single throws to lock it. The loose ends of the suture were cut. The location of this deep stitch made the manipulation of the instruments more challenging. The second task involved the insertion of a continuous skin suture using 6-0 polypropylene (Prolene; Ethicon) in a preformed skin wound (Figure, A). The task commenced with a 3-1-1 knot placed beyond the skin wound to anchor the suture. The needle was then passed subcutaneously and regrasped inside the wound edges after which 3 subcutaneous bites were performed bringing the skin edges together. The needle was then passed from inside the wound edges and brought up through the skin (parallel to the wound), allowing a final 3-1-1 knot to be applied to secure the distal end of the continuous skin closure task.

For both tasks, a standardized wet laboratory environment was used for all surgeons undergoing testing, with the same instruments, surgical skills board (Royal College of Ophthalmologists, London, England) (Figure, A), and unmounted sutures being provided to all subjects. Subjects were allowed time to familiarize themselves with the environment, but once testing commenced, they were required to complete each task a single time without stopping or restarting.

Statistical analysis was performed using the Kruskal-Wallis test on SPSS (version 14; SPSS Inc, Chicago, Illinois). Statistical significance was set at 0.05. A nonparametric test was chosen because of the sample sizes in each cohort.

RESULTS

Summaries of path length, number of movements, and time are presented in the Table. The results demonstrate significant differences in path length, number of movements, and time taken to complete both surgical tasks, with more experienced surgeons demonstrating greater efficiency in completing the given tasks.

Highly statistically significant differences were found between the 3 grades of surgeons for both tasks. For the placement of the deep suture (task 1) (Table), the greater the degree of experience, the shorter the path length (Kruskal-Wallis, P < .001), the lesser the number of hand movements (Kruskal-Wallis, P < .001), and the shorter the time taken (Kruskal-Wallis, P < .001). For the placement of the subcutaneous skin closure (task 2) (Table), the greater the degree of experience, the shorter the path length (Kruskal-Wallis, P = .002), the
Table. Summary of Results for Deep Suture and Skin Closure Tasks

<table>
<thead>
<tr>
<th>Skill level</th>
<th>Deep Suture (Task 1)</th>
<th></th>
<th></th>
<th></th>
<th>Skin Closure (Task 2)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Median (Range)</td>
<td>P Value</td>
<td>Mean (SD)</td>
<td>Median (Range)</td>
<td>P Value</td>
<td>Mean (SD)</td>
<td>Median (Range)</td>
</tr>
<tr>
<td>Novice</td>
<td>2.36 (2.01)</td>
<td>1.73 (6.28)</td>
<td>&lt;.001</td>
<td>6.79 (3.59)</td>
<td>7.00 (8.99)</td>
<td>&lt;.001</td>
<td>6.79 (3.59)</td>
<td>7.00 (8.99)</td>
</tr>
<tr>
<td>Intermediate</td>
<td>1.53 (0.36)</td>
<td>1.49 (1.03)</td>
<td>&lt;.001</td>
<td>4.53 (1.51)</td>
<td>3.95 (4.70)</td>
<td>.002</td>
<td>4.53 (1.51)</td>
<td>3.95 (4.70)</td>
</tr>
<tr>
<td>Expert</td>
<td>0.68 (0.20)</td>
<td>0.67 (0.58)</td>
<td>&lt;.001</td>
<td>2.03 (0.64)</td>
<td>1.71 (1.51)</td>
<td>.002</td>
<td>2.03 (0.64)</td>
<td>1.71 (1.51)</td>
</tr>
</tbody>
</table>

The recent drive to develop more objective and standardized systems of evaluation for surgical trainees has been propagated by current changes in both the content and delivery of medical education. Techniques that have evolved in ophthalmology so far, though useful, have retained an assessor-dependent element of subjectivity. Kinematic and motion analysis is a purely objective tool in both its acquisition and analysis of data. The data presented in this study show the ability of motion analysis to objectively discriminate between surgeons of differing levels of experience. For both oculoplastic tasks assessed, the more experienced the surgeon, the more efficiently they completed the tasks (with shorter path lengths, fewer hand movements, and less time). These results show construct validity, the ability to discriminate between surgeons of different experience, when applied to these oculoplastic tasks.

As shown in the Table, the spread, range, and standard deviation of the parameters narrow as the skill level progresses. The results suggest that with greater experience there is a conflation of surgical skills and that this effect is more pronounced with the more complicated the task (skin closure).

Poor clinical outcomes can result from inadequate technical skill, but despite this, there have been few formal attempts to evaluate it. There has recently been a drive toward an expanded set of tools for surgical evaluation beyond those currently tested in written, clinical, and oral examinations. The Accreditation Council of Graduate Medical Education has endorsed the inclusion of surgical competence as one of the competencies of ophthalmology residents. Similar changes are taking place in Europe. Motion analysis may have a role in helping formulate an objective and standardized system for appraising technical skill.

The surgical tasks selected evaluated specific components of technical competence in a wet laboratory environment and thus have inherent limitations. These tasks, however, were selected to represent core oculoplastic skills that residents should be familiar with and to be of different complexity. This tool has the potential for providing structured objective feedback on surgical performance that may be used to monitor progress and target further tuition and thus be a useful adjunct to current systems of evaluation.

Further research on the practical implementation of this method is required, including its potential to evaluate live surgery. Motion analysis, using a different technology, has been successfully applied to corneal suturing under the microscope. It is encouraging that this form of motion tracking technology, which to our knowledge has not been used for surgical evaluation previously and is more sensitive than other similar tools, was successfully adapted to oculoplastic surgery. You can escape bad teaching but not bad assessment. Good assessment procedures are fundamental for promotion, certification, and licensure. No single method can comprehensively assess the surgical skills of residents in training. Our results offer encouragement that further research takes place in this field, motion analysis will prove to be a useful modality in accomplishing the current goal of more objective surgical evaluation.

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Archives Web Quiz Winner

Congratulations to the winner of our September quiz, Arun Lakshmanan, MS, FRCS, MRCOphth, Department of Ophthalmology, Queens Medical Centre, Nottingham, England. The correct answer to our September challenge was pseudoduplication of the fovea. For a complete discussion of this case, see the Clinicopathologic Reports, Case Reports, and Small Case Series section in the October Archives (Behera UC, Shukla D, Kim R. Pseudoduplication of fovea in a human eye. Arch Ophthalmol. 2007;125[10]:1428-1429).

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