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EDITORS

Minimally Invasive Surgery in Orthopedics

Second Edition

Springer Reference

Minimally Invasive Surgery in Orthopedics

Giles R. Scuderi • Alfred J. Tria
Editors

Minimally Invasive Surgery in Orthopedics

With 1134 Figures and 56 Tables

Springer Reference

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Preface

Since our first edition of ***Minimally Invasive Surgery in Orthopedics***, there has been a growing trend to perform more orthopedic procedures through limited surgical approaches with many using advanced technology to insure accuracy. This second edition continues to cover all anatomic locations with commonly performed procedures. Realizing the current trend towards fast-track surgery, we have expanded the book with sections on rapid recovery programs in joint arthroplasty and joint specific regional anesthesia. All the contributors are experts in their field and have provided the reader with detailed information on their innovative surgical techniques. It is expected that the clinical information and surgical techniques provided in this book, along with tips and pearls, should allow the reader to grasp a comprehensive understanding of minimally invasive surgery. This information will hopefully guide surgeons to perform the procedures safely and effectively with predictable clinical outcomes. We believe this expanded second edition will continue to be a valuable reference for all orthopedic surgeons.

Giles R. Scuderi
Alfred J. Tria

Acknowledgement

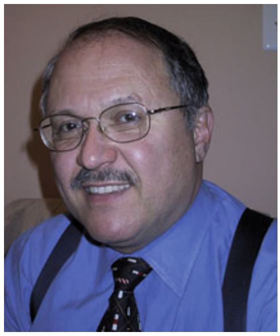
We would like to thank our families for supporting us through all out endeavors, while we continue to pursue our orthopedic dreams.

About the Editors

Giles R. Scuderi, M.D., is Vice President of the Orthopedic Service Line in Northwell Health in New York, an Associate Professor of Orthopedic Surgery at Hofstra Northwell School of Medicine, Fellowship Director of Adult Knee Reconstruction, and attending orthopedic surgeon at Lenox Hill Hospital. Following his residency at Lenox Hill Hospital, he was the Knee Fellow with Dr. John Insall at the Hospital for Special Surgery. His practice focuses on adult knee reconstruction, total knee arthroplasty, and sports medicine.

Dr. Scuderi has published extensively in many medical and orthopedic journals and continues to lecture worldwide on surgical reconstruction of the knee and total knee arthroplasty. He has edited several textbooks, including the first edition of *Minimally Invasive Surgery in Orthopedics*. Dr. Scuderi is past president of the Knee Society and continues an active role as the chairman of the Knee Society Knee Score Outcomes Committee. He is also a member of the American Association of Hip and Knee Surgeons and the Arthroscopy Association of North America.

His philanthropic contributions include being a board member of Operation Walk USA and the Arthritis Foundation New York Chapter.



Alfred J. Tria was born in Brooklyn, New York, and graduated from Harvard College in 1968, and from Harvard Medical School in 1972. He did his general surgery residency training at The Roosevelt Hospital, in New York City, and did his orthopedic residency at The New York Orthopedic Hospital. He completed a Knee Fellowship with Dr. John N. Insall, at The Hospital for Special Surgery, in 1979. He served in The United States Air Force from 1979 to 1981. In 1981, he joined The Department of Orthopedic Surgery at Rutgers-Robert Wood Johnson Medical School in New Brunswick, New Jersey, and has been on the faculty since that time. He has edited 14 textbooks on the knee and published over 200 articles. He is a member of The Academy of Orthopedic Surgeons, The American Association of Hip and Knee Surgeons, and The Knee Society. He is the father of nine children, collects wine, and is an avid pilot.

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Part I

Rapid Recovery Programs for Joint Arthroplasty

What Is Minimally Invasive Surgery and How Do You Learn It?

1

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Innovation in surgery is not new and should not be unexpected. As an example, the history of total joint replacement has demonstrated continuous evolution, and the relatively high complication rates associated with early prostheses and techniques eventually led to the improvement of implants and refinement of the surgical procedures. Gradual adoption of these improvements and their eventual diffusion into the surgical community led to improved success and increased rates of implantation [1]. Increased surgical experience was eventually accompanied by more rapid surgical performance and then by the development of standardized hospitalization protocols, which eventually led to more rapid rehabilitation and return to function. These benefits are well accepted and can be seen as helping contribute to the establishment of a more "consumer-driven" and medical practice.

Most surgeons would agree that as experience guides the surgeon to more accurate incision placement, more precise dissection, and more skillful mobilization of structure, the need for *wide* exposure diminishes. Indeed, less invasiveness appears to be a hallmark of experience gained with a given procedure. From a historical perspective, this appears to be true of total hip replacement. The operation as initially described by Charnley required trochanteric osteotomy. The osteotomy served several purposes: generous exposure, access to the intramedullary canal for proper component placement and cement pressurization, and the ability of the surgeon to "tension"

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the abductors to improve stability. However, over time, it became apparent that trochanteric nonunion and retained trochanteric hardware could be problematic. In attempts to minimize these problems, some worked to develop improved techniques for trochanteric fixation. However, others went in a different direction, eventually demonstrating that the operation could be performed quite adequately without osteotomy. Many purists complained that this was not the Charnley operation and that the *benefits* of trochanteric osteotomy were lost. Yet the eventual acceptance of the nonosteotomy approaches by almost all surgeons performing primary total hip arthroplasty (THA) in the vast majority of circumstances would attest to the fact that osteotomy was not required to achieve the result that had come to be expected.

These developments led to the popularity of the posterior approach to the hip for THA. Initially, the gluteus maximus tendon insertion into the posterolateral femur was routinely taken down to obtain adequate exposure of the acetabulum. Indeed, the generous exposure provided by this release was needed to adequately control acetabular component position, to reduce bleeding for cement interdigitation, and to allow pressurization of acetabular cement. However, this generous exposure was associated with a higher dislocation rate than was seen with the trochanteric osteotomy technique. But with the advent of improved component design (offset) and better understanding of component positioning, as well as the introduction of cementless techniques, less exposure was needed in the majority of cases. Eventually, careful closure of the posterior structures also led to a significant reduction in the dislocation rate [2]. Seen in this example is a finding typically noted in the close examination of most evolutionary processes: initial benefits are obtained at some expense in the form of new or different complications or alterations in the complication rate. Further modifications are then required to overcome the new problems that arise from the adaptation of the innovation. The study of the factors that lead to the adoption (and alterations) of innovations has been extensively studied by Rogers and is well described in his landmark work, the *Diffusion of Innovation* [3].

The trend to *less* or minimally invasive procedures has been noted in other specialties [4] and perhaps can be seen most dramatically in the field of interventional radiology [5].

It would be fair to say that almost all surgical techniques improve over time by leading to less invasive approaches, which are frequently adopted only reluctantly by the surgical community. For skeptics, it is instructive to review the career of Dr. Kurt Semm [6]. His reports of surgical techniques were shouted down at professional meetings and his lectures were greeted with "laughter, derision, and suspicion." He was forbidden to publish by his dean, and his first papers submitted were rejected because they were "unethical." The President of the German Surgical Society demanded that his license be revoked and he be barred from practice. His associates at the University of Kiel asked him to have psychological testing because his ideas were considered so radical. Despite this opprobrium, he invented 80 patented surgical devices, published more than 1,000 scientific papers, and developed dozens of new techniques. His obituary in the *British Medical Journal* hailed him as "the father of laparoscopic surgery." Who today would choose a standard open cholecystectomy over the benefits of the laparoscopic approach?

Hip replacement is currently being performed by a variety of minimalist modifications of the standard hip approaches as well as by nontraditional approaches. Knee replacement is similarly being attempted through shorter incisions with various arthrotomy approaches. The proponents of all call them *minimally invasive*, but this term has really become a catchall and has no specificity or agreed-upon meaning.

The purported benefits of these techniques include earlier, more rapid, and more complete recovery of function, less perioperative bleeding, and improved cosmesis. There has been, to date, few data by other than those proponents of specific techniques to substantiate any of these potential benefits. Of course, these purported benefits must be weighed against their potential to change the nature and/or incidence of complications that may arise secondary to the modifications of these approaches.

There is general consensus that adoption of new techniques initially results in a greater incidence of complications. This is the so-called learning curve [7, 8], well known to all surgeons learning a new procedure. Whether this learning curve is extended or contracted has been shown to depend on both individual and the systemic features of the operation [9].

It should therefore come as little surprise that, in the hands of those initially reporting these modified procedures (and presumably who have developed their expertise gradually and over considerable time), the complication rates are comparable to those found in the standard approaches while others report a higher complication rate [10–14]. There has been insufficient time for the scientific evidence to accumulate in sufficient volume to clarify the specific benefits and risks of these modifications in the hands of specialist surgeons, let alone the generalist who performs these procedures.

Clearly, the modern era's communication technologies, coupled with more sophisticated marketing techniques, have dramatically influenced the speed with which new techniques are recognized, popularized, and thus demanded by an easily influenced public. However, continued accumulation of data through the performance of appropriate studies will eventually determine the most appropriate role for these techniques in the orthopedic surgeon's armamentarium [15]. Prior to that occurrence, what is the surgeon to do?

A purely prescriptive approach is prohibited by the multifactorial nature of the surgical endeavor. The vast majority of surgeons who perform THA on a regular basis have already modified their operative approaches to incorporate less invasive techniques. Each surgeon has an individual tolerance for and willingness to undergo the struggles involved in learning a new procedure, differing levels of commitment to the change required for the performance of the technique, as well as a varying ability to tolerate the potential complications encountered while on the so-called learning curve. Unfortunately, the removal of standard visual, auditory, and tactile feedback cues during the performance of these "less" invasive procedures may require the development of alternate cues, which may not be readily available, well established, or assimilated [11]. Thus, the overall complication rate may rise while familiarization with these cues (and the appropriate response to them) matures or while alternate methods of incorporating similar or comparable information are developed. As attempts are made to limit the invasiveness of surgical procedures, surgeons must be prepared to cultivate and take advantage of nontraditional sensory feedback and other alternate visualization methods to direct their efforts. As these evolve, it can be expected that surgical intervention will continue to become less invasive.

The ultimate question implied in the title of this chapter, that is, how to learn a minimally invasive surgery (MIS) technique, can only be answered by first understanding the current methods of surgical training and their relationship to the practice requirements of standard orthopedic procedures. Only then can we evaluate the way these methods relate specifically to the requirements of MIS and so answer the question: Do the specific surgical requirements of the MIS procedure require an alteration in the manner in which we train surgeons? An additional implied assumption is the perception, which appears to be correct but has not yet been rigorously established, that the performance of minimally invasive procedures in the training environment substantially alters the educational experience for the learning surgeon. A series of linked questions is raised that deserves inquiry: (1) What are the performance requirements for MIS surgery? (2) Do they differ substantially from that of routine non-MIS surgery (begging the question of whether we really understand these!)? (3) What are the relationships between surgical training methods and patient outcomes and do we understand these relationships sufficiently well to proceed to alter them in a meaningful fashion? (4) Does the routine adoption of MIS surgical procedures alter the current teaching environment in a way that is deleterious to the learning surgeon? (5) To what extent do the answers to the proceeding questions demand the development of new methods for surgical teaching as regards the MIS procedures? And, finally, (6) what form might this take?

The old adage "It takes 1 year to teach someone how to operate, 5 years to teach them when to operate, and a lifetime to learn when not to operate" seems to make the point that, in the surgeon's repertoire, it is the psychomotor skills that are the easiest and most readily taught. The implication is that the psychomotor skills required in the operating room are substantively different (and easier to teach) than the cognitive skills required. But this is clearly simplistic. Surgical performance is based on a continuous feedback loop of psychomotor performance intimately coupled with cognitive function. It is the continuous and ongoing making of decisions (albeit almost always at a subconscious level for the experienced) in the midst of physical performance that influences the quality of the surgical intervention.

To what extent the development of these cognitive and motor skills, and their interaction, governs the eventual outcome is a complex problem that has not yet been fully investigated and remains poorly understood. It has been said, "Many more surgeons have done a video analysis of their golf swing than have evaluated their operative performance." While there are few studies that have effectively evaluated real-time surgical performance characteristics in a meaningful way, even more fundamentally and unfortunately, there is little research in the realm of surgical education that would help us determine the specific performance requirements for most surgical procedures in general and of less invasive procedures in particular. Additionally, there are few data on the pedagogical aspects of surgical procedure training for either minimally or maximally invasive procedures. A recent comprehensive review of expert performance indicates that there has been more attention directed to the study of musicians, athletes, pilots, and military commanders than to surgeons [16]. Clearly, however, advances in surgical technology and technique have led to a renewed interest in these issues.

While the performance of arthroscopic procedures has resulted in a premium on specific three-dimensional spacio-visualization and psychomotor applications [8, 17], the same is not necessarily true for MIS-type joint replacement procedures. The simple answer to the question regarding the performance skills requirements for MIS surgery is that they are basically those that are found in standard surgical procedures but taken to a higher level. This arises from specific conditions that appear to be inherent in MIS surgery [9].

1. In some respects, the ability to "protect" structures in the standard fashion may be altered in specific ways unique to the surgical procedure, and this may result in a directly proportional decrease in the margin of error for various intraoperative maneuvers.
2. Small errors during the course of the operation may be less easily recognized, and adjusted for, as the procedure progresses, and the implications of these small errors are potentially magnified.
3. Specific anatomic features that increase the degree of difficulty encountered in the performance of a more "open procedure" (stiffness, deformity, poor tissue quality) may be magnified when the procedure is performed in a minimally invasive fashion.
4. Finally, and perhaps most importantly, the development of minimally invasive techniques frequently involves the removal or diminution of traditional feedback signals that surgeons normally use and have come to rely upon to make continuous adjustments to their performance. Thus, skills that are little needed, are infrequently utilized, or have not been previously recognized become of greater consequence. Indeed, the loss of standard cues may need to be compensated for in technique-specific ways. Ironically, in the hands of the more experienced surgeon, many of these feedback signals are no longer "conscious," having been assimilated into almost automatic motor responses; this can make the relearning process required more difficult.

Training surgeons to perform these more difficult techniques, both with less room for error and with a different set of feedback signals, would therefore seem to require the development of both traditional surgical skills and new ones in ways that guarantee a more demanding performance level than has traditionally been required.

The questioned need for new training methods implies two separate factors that may be driving this concern. First, are current training methods adequate to the task as currently envisioned? Second, does the conversion in the training environment from standard open to MIS procedures degrade the training experience? The answers can be found by evaluating the features of MIS procedures already noted:

1. Visibility of the surgical field is reduced, compromising visual feedback not only to the performing surgeon but also to the learning surgeon dependent upon observation and demonstration of anatomy and surgical pathology.
2. Lowered margins for error limit the opportunities awarded to the less experienced trainee.
3. The decreased ability of the instructor to monitor trainee performance degrades the learning environment.
4. The alteration of traditional cues and their replacement with more subtle and poorly defined feedback signals are hallmarks of MIS techniques. Thus, the replacement of standard open surgery by the MIS procedure would appear to significantly alter the training environment.

Are the traditional residency education and continuing medical education (CME) surgical training methods capable of meeting this standard? The system as currently constituted is derived (with little improvement and perhaps even development of some newer flaws) from the traditional systems of apprenticeship that began sometime between the Dark Ages and the development of city-states in the Renaissance [18]. This pedagogical method, adapted by the German surgical schools of Kocher and Billroth, and modified in the United States by Halsted, has changed relatively little over the years. Thus, training methodologies used to teach surgical skills remain relatively primitive and have enjoyed little improvement in either theory or practice over the decades. Yet the specific technical requirements of the surgical procedures increase steadily. The combined requirements of residency education, that is, service and education, frequently seem to serve the best interest of neither. Even worse, depending on the specific setting, current training methods may be applied unevenly and randomly to the resident participants [19]. The common cliché, see one, do one, teach one, seems to summarize the cavalier approach to procedural teaching that has been the mainstay of surgical pedagogy. Moreover, when real patients are used for surgical teaching purposes, increased morbidity, prolonged intervention times, and suboptimal results may be expected [20]. It is clear that future technologies, whether they be traditionally surgical or otherwise procedurally interventional, will require more, rather than less, highly structured training and assessment methods. It has been demonstrated that laparoscopic surgery adapts poorly to the standard apprenticeship models for general surgical training. Rather, standardized skill acquisition and validation, performance goals, and a supervised, enforced, skill-based curriculum that readily can be shared between trainee and instructor are thought to be needed to replace the observation and incremental skill acquisition model used in an open surgical environment [21].

Assuming no dramatic change in the nature of our economy and the emphasis on health care, it is not likely that the drive toward less invasive techniques will abate. As technology matures, new and improved techniques for vital structure protection, component placement and positioning, and bone and soft tissue management will come on line. As they do, the gradual development of improved skill levels in the performance of standard procedures coupled with the cautious adoption of new practices as these skills mature is warranted. An understanding of the ethical and moral responsibilities of the operating surgeon must be understood as they relate to training and surgical performance [22]. An open mind along with a critical eye will be required. The following suggestions can be offered to the surgeon who has yet to adopt these techniques.

How to Learn MIS: Practical Suggestions

It has been demonstrated that domain-specific and task-specific skills are not necessarily readily transferred to new domains or tasks in the surgical environment [23–25]. Surgeons, like other adults, learn best by doing, by practicing what they do, and by challenging themselves to take on increasingly difficult scenarios. Practice, in order to be effective, requires deconstruction of the actual procedure into key elements, each of which is repeated until optimal results are achieved before moving onto the next element. The key ingredient to successful practice and ultimate self-improvement as a surgeon, as in other pursuits in life, is that one be self-motivated and competitive, with a strong desire to improve coupled with appropriate practice routines that can lead to improvement. This calls to mind the old joke, "Mister, How do I get to Carnegie Hall?" The answer, of course, is "practice."

Incremental Improvement Through Practice

The literature on CME provides no support for the hypothesis that didactic CME improves either practice patterns, skill levels, or patient outcomes – from this, one can infer that surgeons learn the more complex domain of surgical performance through repetition of procedures [26]. Willingness to engage in repetitive attempts at improving the quality of what one is doing is crucial. One needs to define clearly the areas requiring practice and employ a gradual, repetitive practice pattern; ultimately, one either improves or must change practice habits. This is particularly important in developing an action plan for surgeons who may not currently be performing any MIS procedures.

Practice

Correctpractice begins with the breakdown of the procedure into its component parts, focusing performance-based exercise on those component parts and acquiring and recognizing feedback, both during the performance in real time and after. As an example, surgeons who are the most experienced in total knee replacement arthroplasty (TKA) frequently perform the vast majority of the needed soft tissue releases to balance the knee during the initial approach and exposure of the knee. Less experienced surgeons tend to make the soft tissue releases a separate part of the technique, independent of the exposure, while the more experienced surgeon utilizes feedback throughout the procedure and employs it to guide the degree of tissue they are releasing during the exposure. In order to master the new skills that may be required in minimally invasive approaches, the surgeon must reenter the mind of the learner that was present at an earlier stage of training. The basic steps must be isolated, and renewed attention must be given to the details of procedure used to isolate those parts of the operation that require more attention, and there must be a detailed focus on accomplishing the specific tasks required at each step of the procedure, specifically, on how they present new or different challenges. Those steps that require the acquisition of new or refined skills can then receive the appropriate attention. The use of computer guidance can aggressively strengthen feedback loops for surgical technique that might otherwise take years to develop. The precision of the technology provides objective and exacting criticism.

Criticism

Another contributor to effective practice is self-grading. Over time, one increases the pressure on oneself to perform, grades the result, and seeks to improve. Self-grading requires measurement, and one needs to have some surgical goals in mind, such as tourniquet time, time to complete the procedure, or specific objective characteristics of operative performance – cement mantle quality, component position, limb alignment, etc. For more detail on this technique, see the Debriefing section below.

Varied Pressure

Surgeons can expand or contract the amount of pressure experienced, because these less invasive approaches and the procedures themselves are, for the most part, relatively extensile. Beginning a TKA as an MIS procedure does not lock the surgeon into that pathway; if, at any point, the surgeon deems the case too complex or the soft tissue considerations are becoming unexpectedly difficult, no harm is done by increasing the size of the incision to expand the exposure. Surgeons can literally "push the envelope" by working their way from the larger incision down to the smaller and, as a consequence, gradually increase the pressure on themselves. But the surgeon can also reduce that stress when desired or, more importantly, when necessary to achieve the optimal surgical outcome.

Avoid Multiple Learning Curves

It is essential to avoid combining multiple learning curves when learning a new procedure. The outcome of any surgical intervention is clearly multifactorial. Beyond the limitation of one's own surgical skill set and one's intuition, each operation encompasses a complex set of multiple factors, some of which may remain below the radar screen of the most experienced surgeon. These factors include, but are not limited to, the relative contributions of our assistants, the characteristics of the specific operating room, and the type of anesthesia being used. Multiple alterations to such a complex system are much more difficult to assimilate than the incremental addition of small changes approached one at a time. For example, it would be less than optimal to try a new technique or a new approach with new instruments, a new implant design, a new scrub technician, and a new surgical assistant all at the same time. Avoiding multiple learning curves is essential in ensuring that the pressure you exert upon yourself represents a systematic increase and not an overload; you can sequentially add more complexity and variation as you get better at what you do.

Visualization

Another important technique that has been well publicized in other areas of psychomotor skill acquisition and performance, but not as well publicized in surgery, is the use ofvisualization techniques. Great athletes will all admit to using visualization as an important part of their practice regimen. Similarly, most high-performing surgeons will also rehearse the operation, literally in their "mind's eye," before proceeding with the case. Most of us who perform complex surgery have the experience of repeatedly reviewing the steps and sequences in a new operation beforehand, particularly when learning something completely new.

Visualization has been used in sports, musical performance, and in other forms of physical activity, including dance and even acrobatic flying. Acrobatic pilots not only visualize the expected sequence of flight maneuvers in their minds along with the control manipulation needed to achieve them but also assume the corresponding body postures, as if they are experiencing the forces associated with the acrobatic flight maneuver. This visualization technique combines psychomotor and cognitive skill sets. One can similarly see downhill ski racers mentally rehearsing the race course, accompanied by hand and body motion. In the same way, surgeons using similar visualization might "think through" a particular operation sequentially while imagining the potential problems, structures at risk, and specific goals of the procedure, while actually positioning their hands as if they were grasping a specific instrument for a specific task during a surgical procedure.

Debriefing

Another self-improvement method involves debriefing, a more formal model for self, group, or mentor after-activity assessment [27, 28]. The classic role of debriefing is in the military, where it has been used for generations to train and improve the skills of warriors, particularly pilots.

Debriefing or after-action reviews involve the meticulous creation of a specific checklist of the goals of any given performance followed by the ruthless assessment of how those goals were actually met during the performance. Debriefing techniques have applications in teaching residents and fellows as well as in improving one's own performance. Such sessions have an important role in improving performance at the step where you are at as well as in successfully ascending the ladder of surgical complexity [29].

Team Approach: Coaching

The MIS effort generally leads to an appreciation of the importance of teamwork and its impact on surgical outcome. Perfect performance of the operation without appropriate attention given to perioperative factors, such as pain control, rehabilitation, etc., will not yield an optimal result. Similarly, increased coordination between assistants and surgeon is another requisite for the successful performance of this more demanding type of surgical procedure. Thus, a continuous focus on the need for a team approach throughout, from preoperative considerations, to the surgical phase, and continuing through to the postoperative environment, is a key determinant of optimal outcome. Every team needs a coach, and, in most cases, the responsibility will and should rest with the surgeon. What do coaches do? Their primary role is to create a feedback loop; this is done by developing performance expectations, monitoring performance in a critical way, and, finally, providing feedback that leads to improvement and both motivates and empowers team members.

The Future

The characteristics that make up surgical performance include preoperative, intraoperative, and postoperative factors. While the focus on surgical training must be on all three arenas, it is mainly the intraoperative phase, where actual physical skills are required, that is seen by most trainees as being the area where there is the least opportunity to develop experience. Experience is ideally gained in an environment where feedback is immediate and mistakes are tolerated as part of the learning experience. One of the things that have prevented surgeons from acquiring greater levels of skill prior to entering practice or even during practice is the lack of such a practice environment.

The performance of surgery itself is dependent on performing multiple "subroutines," most of which have only been available for the surgeon to experience during the performance of actual surgical procedures and therefore present the surgeon with no real opportunity to "practice" the psychomotor skills required during the procedure. In addition, there is little in the way of immediate information available to the surgeon during the course of the operation that would allow the surgeon to make the type of adjustments that are based on cause-effects/feedback loops. As noted earlier, even in the performance of physical skills, there are multiple cognitive processes that must function correctly and efficiently to maximize surgical performance.

With modern technology, many of the factors that contribute to surgical performance can be simulated and repeatedly experienced with immediate feedback on the correctness of decisions and behaviors. Development and utilization of this technology would be expected to result in any given surgeon moving more rapidly along the learning curve, allowing the surgeon to perform at a higher level during the actual surgical encounter. Despite the obstacles present to the current employment of actual psychomotor skill simulation, these devices will eventually be part of the surgical training environment. In the coming era of virtual reality environments and surgical training simulators, there is good reason to believe that the coupling of these technologies to assist the surgeon in acquiring both motor and cognitive skills will result in improved surgical performance as well as improved patient outcomes as a result of the clinical encounter.

A current potential model for improving surgical responsiveness and judgment can be obtained by using the interactive video game as a model. Several features of the modern interactive video game make it both compelling and popular. One