RESEARCH ARTICLE

# Successful Outcomes Achieved Via Web-based, Home Program after Total Shoulder Arthroplasty

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## Abstract

**Background:** The primary goals of total shoulder arthroplasty (TSA) are to relieve pain, improve range of motion, and restore function. Physical therapy is commonly used to help achieve these goals. Recent evidence has pointed to the success and safety of a purely physician-guided, home-based or internet-based, program versus the traditional therapist guided program.
The purpose of this study was to evaluate outcomes of TSA in patients using a web-based, home therapy program.

**Methods:** A retrospective review was performed of TSA patients who were given the option of using a web-based, home therapy program. Functional outcomes were collected preoperatively, 6-month, and 12-month post-operative examinations. Physical examination parameters were recorded at preoperative, 3-month, 6-month, and 12-month time-points.

**Results:** Forty-seven patients used the web-based, home therapy program and had complete follow-up data at all time intervals. All mean range of motion parameters and functional scores improved significantly from preoperatively to postoperatively. There was one reported complication in a patient who sustained a subscapularis rupture and underwent subsequent open repair at 10 months postoperatively.

**Conclusion:** This study demonstrates successful improvements in range of motion and functional outcomes in a subset of patients who utilized an online therapy program after TSA. Future study will be necessary to directly compare results in patients enrolled in formal, outpatient therapy programs and to determine barriers to utilization of web-based therapy programs.

**Level of evidence:** IV

**Keywords:** Home therapy, Patient guided therapy, Shoulder therapy safety, Total shoulder arthroplasty, Web-based therapy

## Introduction

Anatomic total shoulder arthroplasty (TSA) has been established to be an effective treatment option for glenohumeral arthritis. Results have found significant improvements in range of motion and pain relief with good to excellent long-term results (1). Additionally, modern component design and technique improvements have led to a decrease in complication rates (2). TSA also provides improvement in general quality of life outcome measurements (3, 4). Due to these successful outcomes, the prevalence of TSA is increasing at rates exceeding those of total hip and knee arthroplasties (5).

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As with most shoulder surgery, the success of a total shoulder arthroplasty relies heavily on a well-designed and executed rehabilitation protocol (6, 7). Therapy protocols generally involve a graduated stretching program followed by a graduated strengthening program. While the timing of when to start these exercises may be debated, the importance of postoperative rehabilitation is widely understood (6, 8). Commonly, these exercises are performed through the guidance of a prescribed, outpatient physical therapy program.

Recent evidence has pointed to the success and safety of a purely physician-guided program versus the traditional therapist guided program (9). Multiple lower extremity randomized controlled trials have demonstrated the safety and success of home based or internet guided physical therapy programs (10-12). This study aimed to evaluate the safety and success of a web-based home physical therapy program for patients undergoing anatomic TSA. We hypothesized that there would be similar clinical and functional outcomes to historic results of TSA.

## Materials and Methods

After Institutional Review Board approval was obtained, a retrospective review was performed of patients who had undergone anatomic TSA and were given the option of using a web-based, home therapy program (Force Therapeutics, New York, NY). The program was designed specifically by the authors and other shoulder and elbow surgeons at our institution. Patients interact with the program throughout the pre-operative and post-operative periods and can also interact with a nurse navigator as well as the surgeon through the online portal. After a patient is indicated for surgery, signs informed consent to undergo a TSA, and indicates ability and interest in utilizing the online system, an email is generated that welcomes them to the program. The patient then has educational materials provided to them in the pre-operative period. Post-operatively, the patient will get daily email reminders of the exercises to be performed that day. At our institution, a standardized therapy protocol is utilized: Phase I followed by Phase II stretching (termed Phase I, Figure 1) in the first 6 weeks


**Figure 1. This example demonstrates the exercises provided for the Phase I portion of the online therapy program. They are also associated with corresponding videos.**

and then Phase I followed by Phase II strengthening (termed Phase II, Figure 2) for the second 6 weeks.

The online portal provides pictures and videos describing how each exercise is to be performed. Each time the patient logs-in and views an exercise it is recorded in the system to help monitor their progress. They are encouraged to ask questions of their nurse navigator or their surgeon within the system.

Once the cohort of patients was identified, demographic information was collected including age, gender, and Charlson Comorbidity Index (CCI). Functional scores collected included the American Shoulder and Elbow

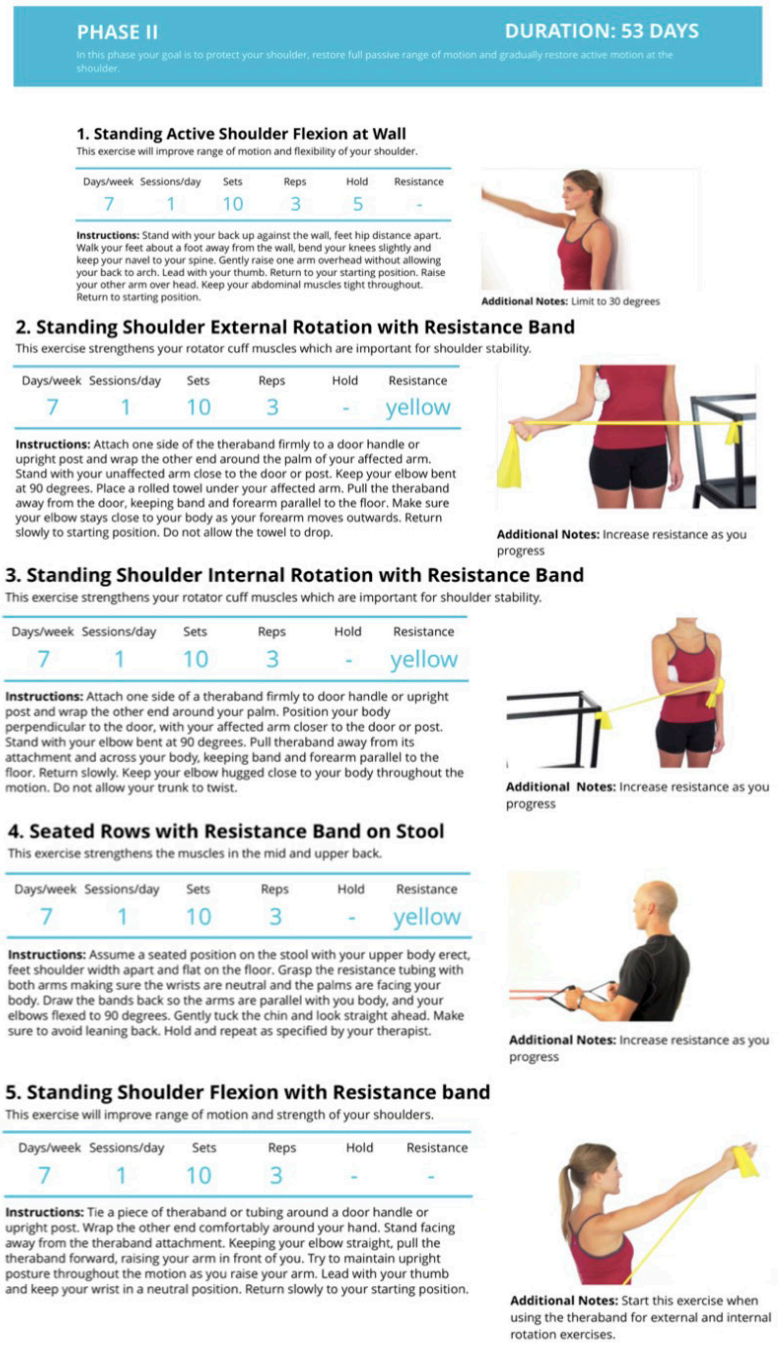


**Figure 2. This example demonstrates the exercises provided for the Phase II portion of the online therapy program. They are also associated with corresponding videos.**

Surgeons (ASES) Shoulder Score, the Simple Shoulder Test (SST), the Single Assessment Numeric Evaluation of the Shoulder (SANE), and the Visual Analog Pain Score (VAS). All functional outcomes were collected pre-operatively and at 6- and 12-month post-operative examinations. ASES is a validated 11 question survey that assesses patient pain and function and is scored out of a total of 100 points. SST is a validated 12-question survey composed of yes/no questions that assess shoulder function and is scored as a percentage of "yes" responses over the 12 possible questions. SANE is a validated single question survey in which a patient is asked to rate his/her shoulder as a percentage of normal (i.e. 100% being totally normal).

Physical examination parameters recorded included active forward elevation and external rotation pre-operatively and 3- months, 6- months, and 12-months post-operatively. Range-of-motion measurements were retrospectively collected from the surgeons' dictated notes. Patients without 12-month range-of-motion and outcome scores were excluded. Follow-up of 12-months was chosen as most arthroplasty patients begin to plateau in their improvement around 6-12 months.

In addition, patient interaction information with the online program was collected. This data included the number of times a patient logged in, the number of messages sent to the clinician by the patient, and the system reported compliance. Compliance is generated as a percentage of available logins the patient used during the pre-operative and post-operative periods as well as percentage of tasks completed per login.

Statistical analysis was performed using reported measure ANOVA analysis to compare range of motion and functional scores from pre-operation to 3-, 6-, and 12-months. When sphericity was not assumed, a Greenhouse-Geisser correction was undertaken. Post-hoc analysis was performed with Bonferroni pairwise comparisons.

## Results

This program was initiated at our practice in late 2014 and the goal of this study was to evaluate patients with a minimum of one-year follow up. Therefore, records were reviewed between November 2014 and March 2016, during which time 196 patients underwent a TSA and were offered to use the web-based therapy program. Twenty-six patients opted out of the online program after receiving the invitation email.

Forty-seven of the remaining 170 patients identified used the web-based, home therapy program and had complete one-year follow-up data at all time intervals. There were 28 men and 19 women with a mean age of 66.3 years old (range 38 – 85) and a mean CCI of 3.74 (range 2 – 6). All mean range-of-motion parameters and functional scores significantly improved from pre-operatively to post-operatively [Table 1 and Figures 3; 4].

The average number of patient logins to the system was: pre-operatively 2.2 (range 0 – 20) and post-operatively 33.3 (range 0 – 115). The mean number of messages sent to the clinician through the portal was 2.9 (range 0 – 20). The average compliance of logins during the perioperative period was 23.1% (range 0 – 86) and compliance of tasks completed per login was 66.0% (range 0 – 100). Compliance of logins is the number of times a patient logged into the system compared to the total number of login days available to them. Compliance of tasks is the number of tasks completed out of the total number prescribed.

There was one reported complication in a patient who sustained a traumatic rupture of the subscapularis while playing golf and underwent subsequent open repair at 10-months post-operatively. There were no other complications, readmissions, or reoperations.

## Discussion

This retrospective study evaluated the efficacy of a web-based home physical therapy program for anatomic TSA and found the protocol to have excellent clinical and functional results. Similar to prior studies on outcomes from anatomic TSA, we found significant improvements in range-of-motion, with average forward elevation and external rotation nearing normal ranges of 155° and 45°, respectively. Additionally, we found significant improvements in ASES, SST, and SANE scores as well as

**Table 1. Mean range of motion and functional outcome data as recorded at the preoperative visit as well as at 3-, 6-, and 12- month post-operative time points. Statistically significant improvements were seen for all functional and motion parameters. AFE= Active forward elevation; ER= External rotation; ASES=American Shoulder and Elbow Surgeons score; SST= Simple Shoulder Test score; SANE= Single Assessment Numeric Evaluation score; VAS= Visual Analog Pain score; NC=not collected.**

| Follow-up (mos) | 0 | 3 | 6 | 12 | *P-value* (0 v. 12) |
|---|---|---|---|---|---|
| FE | 110±28 | 141±25 | 155±17 | 155±19 | <0.001 |
| ER | 22±16 | 39±10 | 46±12 | 45±12 | <0.001 |
| ASES | 39.4±17.2 | NC | 83.6±12.7 | 86.7±16.2 | <0.001 |
| SST | 33.53±20.62 | NC | 79.07±22.09 | 84.26±22.16 | <0.001 |
| SANE | 34.55±24.57 | NC | 78.87±16.62 | 80.19±24.32 | <0.001 |
| VAS | 6.0±2.3 | NC | 1.1±1.4 | 1.5±2.1 | <0.001 |

FE: Forward Elevation; ER: External Rotation; NC: Not collected

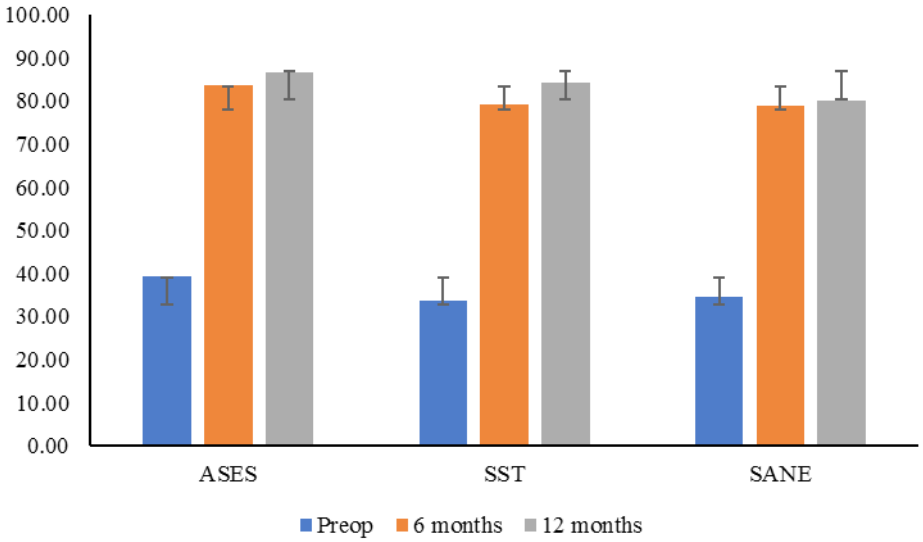


**Figure 3. This graph shows the significant improvements in functional outcome scores achieved at the 6- and 12-month time points. Significance is provided for each survey respectively (*P<0.001* for all comparisons). ASES=American Shoulder and Elbow Surgeons score; SST= Simple Shoulder Test score; SANE= Single Assessment Numeric Evaluation score; VAS= Visual Analog Pain score.**

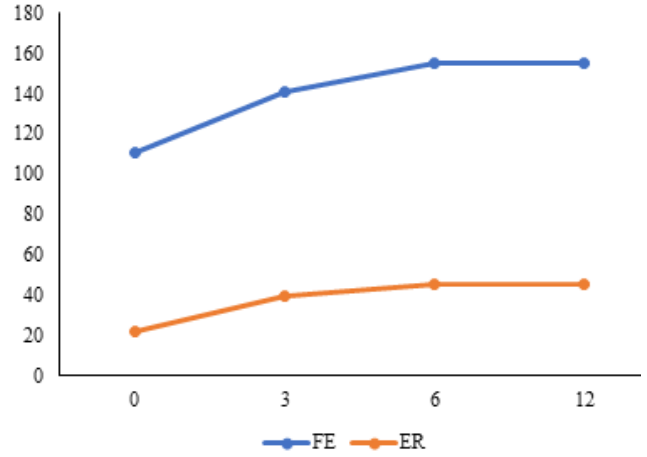


**Figure 4. This graph shows the improvement in range of motion. As is typical with many shoulder procedures, the largest gains are made in the first 6 months with incremental improvements thereafter. AFE= Active forward elevation; ER= External rotation. Significance is provided for each range of motion measurement; comparisons made to pre-operative values were all significant at *P<0.001* (i.e.*†¥). For AFE ˆ*P<0.001* and ‡*P<0.001*. For ER ˆ*P=0.014*.**

a significant reduction in pain when compared to pre-operative assessments.

In the complex American health system, an emphasis is being placed not only on striving for improved outcomes of surgical procedures but also minimizing the cost involved. One strategy that has been established is bundling payments for an entire episode of care for a specific procedure (13). This innovative approach has led clinicians and administrators to define the aspects of each episode as being of high or low value. Those facets which are low value, meaning their costs exceed their benefit, are at risk of being eliminated if a safe alternative can be supplied at a lower cost.

As mentioned above, physical therapy plays an integral role in the rehabilitation of the post-operative orthopaedic patients. However, it has come into question as to whether traveling to a physical therapy center is necessary after undergoing joint arthroplasty. In the hip arthroplasty literature, Austin el al. completed a randomized controlled trial evaluating the need for any therapy after total hip arthroplasty. The authors found that a home based, patient guided program was as safe and efficacious as formal therapy (4). Two recent randomized controlled trials examined patients undergoing total knee arthroplasty who underwent formal physical therapy versus a telerehabilitation program. Both studies found non-inferiority of the telerehab program when compared to the traditional program (11, 12). Beyond the improved cost savings of eliminating multiple therapy visits, there is also the time savings of not having to travel to a therapy center multiple times per week.

While it is becoming well established that hip and knee arthroplasty therapy can safely be done at home, few studies have examined this in total shoulder arthroplasty patients. Mulieri et al retrospectively examined two cohorts of patients who had used formal physical therapy versus a physician guided program after TSA. They found no difference in functional outcome scores and slight improvements in final range-of-motion parameters in

the physician guided group (9). This study certainly gives credence to the concept of a home based therapy program after total shoulder arthroplasty. However, with the relative complexity of the exercises compared to those of hip and knee rehabilitation, having more instruction, even if virtual, may be of benefit to the patient. While we cannot assess the quality of exercises performed by patients, home exercises are an important aspect of any rehabilitation program, and we believe our visual aid provides a more robust instructional process. We found that patients logged in to the system regularly in the post-operative period, an average of 33 times. While the total percentage of available logins was low (23%), the percentage of exercises completed once a patient logged in was high (66%). The ability to track patients progress on a daily basis is an advantage of this online based program. While it was not explored in this study, future goals will be measuring patients' range-of-motion with wearable technology to be able to provide further assistance to those who are falling behind.

There are limitations in this study, most notably its retrospective design. In the early phase of using this system there was a technologic barrier to involvement, which made a prospective study difficult at the time. This hindered our ability to measure full and complete outcomes on all patients. Second, this study lacked a true control group to compare outcomes. While this is a limitation, we did not find our outcomes to be drastically different than those reported in many other studies on TSA. Finally, this study was performed during a time when this technology was just being released in our practice. Therefore, while the outcomes of those patients involved were excellent, there is ample opportunity to include more patients as we move forward with this technology.

In conclusion, we evaluated a new approach to performing therapy in the patient undergoing total shoulder arthroplasty. This system does not require additional visits with the surgeon or any visits with a therapist if that patient is moving on target. It allows the patient as well as the physician to actively monitor progress and easily communicate throughout the rehabilitation process. Additionally, it provides excellent outcomes equivalent to those expected of modern shoulder arthroplasty at a reduced cost. Further prospective, comparative studies would be helpful to more fully identify the barriers to successful implementation of this system as well as to define any limitations it may have in producing successful results.

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## References

1. Deshmukh AV, Koris M, Zurakowski D, Thornhill TS. Total shoulder arthroplasty: long-term survivorship, functional outcome, and quality of life. Journal of shoulder and elbow surgery. 2005; 14(5):471-9.
2. Chin PY, Sperling JW, Cofield RH, Schleck C. Complications of total shoulder arthroplasty: are they fewer or different? Journal of shoulder and elbow surgery. 2006; 15(1):19-22.
3. Carter MJ, Mikuls TR, Nayak S, Fehringer EV, Michaud K. Impact of total shoulder arthroplasty on generic and shoulder-specific health-related quality-of-life measures: a systematic literature review and meta-analysis. JBJS. 2012; 94(17):e127.
4. Austin MS, Urbani BT, Fleischman AN, Fernando ND, Purtill JJ, Hozack WJ, et al. Formal physical therapy after total hip arthroplasty is not required: a randomized controlled trial. JBJS. 2017; 99(8):648-55.
5. Day JS, Lau E, Ong KL, Williams GR, Ramsey ML, Kurtz SM. Prevalence and projections of total shoulder and elbow arthroplasty in the United States to 2015. Journal of shoulder and elbow surgery. 2010; 19(8):1115-20.
6. Brems JJ. Rehabilitation following total shoulder arthroplasty. Clinical orthopaedics and related research. 1994 (307):70-85.
7. Bruzga B, Speer K. Challenges of rehabilitation after shoulder surgery. Clinics in sports medicine. 1999; 18(4):769-93.
8. Denard PJ, Lädermann A. Immediate versus delayed passive range of motion following total shoulder arthroplasty. Journal of shoulder and elbow surgery. 2016; 25(12):1918-24.
9. Mulieri PJ, Holcomb JO, Dunning P, Pliner M, Bogle RK, Pupello D, et al. Is a formal physical therapy program necessary after total shoulder arthroplasty for osteoarthritis? Journal of shoulder and elbow surgery. 2010; 19(4):570-9.
10. Mahomed NN, Davis AM, Hawker G, Badley E, Davey JR, Syed KA, et al. Inpatient compared with home-based rehabilitation following primary unilateral total hip or knee replacement: a randomized controlled trial. JBJS. 2008; 90(8):1673-80.

11. Moffet H, Tousignant M, Nadeau S, Mérette C, Boissy P, Corriveau H, et al. In-home telerehabilitation compared with face-to-face rehabilitation after total knee arthroplasty: a noninferiority randomized controlled trial. JBJS. 2015; 97(14):1129-41.
12. Russell TG, Buttrum P, Wootton R, Jull GA. Internet-based outpatient telerehabilitation for patients following total knee arthroplasty: a randomized controlled trial. JBJS. 2011; 93(2):113-20.
13. Barinaga G, Chambers MC, El-Othmani MM, Siegrist RB, Saleh KJ. Affordable care organizations and bundled pricing: a new philosophy of care. Orthopedic Clinics. 2016; 47(4):707-16.