

Impact of Live Interactive Tele dermatology on Diagnosis, Disease Management, and Clinical Outcomes

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Objective: To assess the impact of live interactive tele dermatology consultations on changes in diagnosis, disease management, and clinical outcomes.

Design: We conducted a retrospective analysis of 1500 patients evaluated via live interactive tele dermatology between 2003 and 2005 at the University of California, Davis. We compared diagnoses and treatment plans between the referring physicians and the tele dermatologists. Patients with 2 or more tele dermatology visits within a 1-year period were assessed for changes in clinical outcomes.

Setting: Academic medical center with an established tele dermatology program since 1996.

Participants: Medical records were evaluated for 1500 patients who underwent live interactive tele dermatology consultation. Patients seen for more than 1 tele dermatology visit were included in the clinical outcome assessment.

Intervention: Live interactive tele dermatology consultation.

Main Outcome Measures: Changes in diagnosis, disease management, and clinical outcome.

Results: Compared with diagnoses and treatment plans from referring physicians, the 1500 live interactive tele dermatology consultations resulted in changes in diagnosis in 69.9% of patients and changes in disease management in 97.7% of patients. Among 313 patients with at least 2 tele dermatology visits within 1 year, clinical improvement was observed in 68.7% of patients. Multivariate analysis showed that changes in diagnosis ($P=.01$), changes in disease management ($P<.001$), and the number of tele dermatology visits ($P<.001$) were significantly associated with improved clinical outcomes.

Conclusions: Live interactive tele dermatology consultations result in changes in diagnosis and disease management in most consultations. The numbers of live interactive tele dermatology visits and changes in diagnosis and disease management are significantly associated with improved clinical outcomes.

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TELEMEDICINE IS AN EVOLVING field that uses technology-enabled health care delivery models to provide patient care from a distance.^{1,2} Telemedicine serves as a valuable tool in the diagnosis and management of skin diseases because cutaneous conditions can be readily examined via digital still or video images. The increasing use of tele dermatology to serve geographically distant communities, medically underserved communities, and veterans attests to the continued growth of tele dermatology applications in the United States as well as other countries.³⁻⁶

Technology-based categorization usually divides tele dermatology into store-and-forward (S&F) and live interactive

(LI) sections. Although the use of S&F tele dermatology appears to be increasing at a higher rate than LI tele dermatology in the United States, the LI method has several distinct advantages. First, LI tele dermatology enables real-time dialogue among the specialist, the patient, and the referring physician.⁷ This interaction enables both patient education and physician education.⁸ Second, LI tele dermatology allows for instant clarification of history and the capture of additional images if the specialist desires more clinical information for diagnosis. However, challenges of LI tele dermatology include coordinating the dermatologists' and patients' schedules for clinic visits, higher cost of technology (videoconferencing equipment and dedicated, secure Internet pro-

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Table 1. Patient Demographics

Variable	Value
Age, mean [SD], y	35.2 [15.4]
Sex, No. (%)	
Male	1132 (75.5)
Female	367 (24.5)
Referred by primary care provider, No. (%)	1490 (99.9)
Time from referral to visit, mean [SD], d	15.0 [22.6]
Visits per patient, mean [SD], d	1.4 [0.9]

toocol connectivity) compared with that used for S&F teledermatology, and image quality issues associated with low bandwidth for transmission of video images.⁹⁻¹¹

Numerous studies¹²⁻¹⁶ have demonstrated acceptable diagnostic accuracy from teledermatology consultations when compared with conventional in-person office visits; however, few studies¹⁷⁻²⁰ have examined clinical outcomes of teledermatology delivery. Studies²¹⁻²⁴ evaluating the use of teledermatology to provide general consultation and skin cancer management have shown equivalence of outcomes with traditional office visits. Teledermatology may be an effective platform through which patients' therapy can be managed successfully by remote specialist consultation. In the present study, we evaluated the impact of LI teledermatology consultations on patient diagnosis, disease management, and clinical outcomes at a major academic medical center with an established teledermatology program since 1996.

METHODS

PATIENT POPULATION

This study was approved by the institutional review board at the University of California, Davis. Between August 26, 2003, and September 2, 2005, a total of 1500 patients were identified from the University of California, Davis Center for Health and Technology database as having had at least 1 LI teledermatology consultation. A total of 1490 patients had complete information for the variables of interest in the electronic medical records system and were therefore included in the study. Of these, 313 had 2 or more LI teledermatology visits during the 1-year period and were eligible for assessment of changes in clinical outcome. Patients were referred from primary care physicians from 31 facilities throughout California, many with limited access to dermatologists. The dermatologists were assigned dedicated LI teledermatology clinics, usually in 4-hour clinic blocks, to care for patients from multiple sites through real-time videoconferencing in a sequential manner. As mandated by California law, all LI teledermatology consultations are reimbursed. Our research staff reviewed each patient's medical record to determine whether teledermatology consultation resulted in changes in diagnosis, changes in disease management, or improvement in clinical outcomes.

ASSESSMENT OF CHANGES IN DIAGNOSIS

A change in diagnosis was defined as whether the consultant dermatologist's diagnosis was different from that of the referring physician's diagnosis at the completion of the initial LI teledermatology consultation. For each patient, the outcome

variable *changes in diagnosis* was recorded dichotomously as either change or no change. If the referring provider was unable to indicate a specific diagnosis (eg, unknown diagnosis) and the dermatologist was able to make a definitive diagnosis, these cases were considered to have had a change in diagnosis. If the dermatologist did not provide a specific diagnosis or the initial teledermatology consultation report stated "diagnosis pending further evaluation," we coded these patients as having no changes in diagnosis.

ASSESSMENT OF CHANGES IN DISEASE MANAGEMENT

A change in disease management was defined as whether the dermatologist recommended different treatment plans from those suggested or completed by the referring physician. We categorized changes in disease management as a result of LI teledermatology into the following types: medication initiation or discontinuation, changes in the dosage or vehicle of a medication, ascertainment of laboratory tests not obtained by the referring provider, recommendations of procedural intervention, and recommendations of education and/or observation. Specifically, dermatologist-recommended procedural interventions included biopsy, excision, electrodesiccation and curettage, cryotherapy, intralesional injections, laser treatment, and phototherapy.

The aggregate outcome, *changes in disease management*, included the subcategories of medication initiation or discontinuation, change in dosage or vehicle, addition of laboratory test, education and/or observation, and recommendation for procedural intervention.

ASSESSMENT OF CLINICAL OUTCOMES

Changes in clinical outcomes were assessed for patients who had at least 2 consecutive teledermatology visits for the same primary dermatologic problem (n=313) within 1 year. Two dermatologists independently compared each patient's baseline teledermatology visit with the last recorded teledermatology visit within the 1-year period. *Improvement* was recorded only when there was evidence of clinical improvement documented by the teledermatologist in the follow-up visit. *No improvement* was recorded if there was no change indicated in the subsequent assessment or if the patient's condition worsened.

STATISTICAL ANALYSIS

Patient demographics and frequency of teledermatology diagnoses were reported. Summary statistics were tabulated for changes in diagnosis and management. Univariate and multivariate analyses were performed to assess factors that were significantly associated with improvement in clinical outcomes. All results achieving a *P* value less than .05 were considered statistically significant in the multivariate analysis. Calculations were performed using commercial software (Stata, version 11.0; StataCorp, College Station, Texas).

RESULTS

DEMOGRAPHICS

Patient age ranged from 3 months to 88 years (mean [SD], 35.2 [15.4] years), with 75.5% male (n=1132) and 24.5% female (n=367). The mean (SD) time between referral and initial teledermatology visit was 15.0 (22.6) days (**Table 1**).

CHANGES IN DIAGNOSIS

The spectrum of diagnoses for patients' primary dermatologic problem, according to the LI teledermatologists, is given in the following tabulation:

Diagnostic Category	No. (%) (n=1490) ^a
Inflammatory process	959 (64.4)
Infectious process	242 (16.2)
Benign growth	154 (10.3)
Malignant lesion	76 (5.1)
Premalignant lesion	39 (2.6)
Neoplasm of unknown significance	20 (1.3)

^aPatients with complete information for the variables of interest.

Teledermatology consultations resulted in a change in diagnosis from that of the referring provider in 69.9% of patient consultations (n=1042) (**Table 2**). Among the cases with changes in diagnoses, the top 3 most frequent changes were (1) from the primary care provider's diagnosis of skin infection to the dermatologist's diagnosis of a primary inflammatory process (eg, psoriasis or eczema mimicking fungal infection), (2) from the primary care provider's diagnosis of malignant lesions to the dermatologist's diagnosis of benign lesions (eg, a seborrheic keratosis mimicking melanoma), and (3) from the primary care provider's diagnosis of benign lesions to the dermatologist's diagnosis of malignancy (eg, a basal cell carcinoma mimicking a benign dermal nevus).

CHANGES IN DISEASE MANAGEMENT

The LI teledermatology consultations resulted in a recommendation of initiation or discontinuation of a medication in 67.5% of the cases (n=1006), a change in either dosage or vehicle of a medication in 4.8% of the cases (n=71), the addition of laboratory tests or cultures in 18.3% of the cases (n=272), and observation and/or education in 9.1% of the cases (n=136). Various procedural interventions, including excision, biopsy, electrodesiccation and curettage, cryotherapy, laser, or phototherapy, were recommended in 26.4% of consultations (n=393). Overall, aggregate changes in disease management were observed in 97.7% of patient consultations (n=1455).

IMPROVEMENT IN CLINICAL OUTCOMES

Live interactive teledermatology consultation resulted in an improvement in clinical status between the baseline and subsequent telemedicine consultation in 68.7% of the 313 patients (n=215) with 2 or more LI teledermatology visits.

UNIVARIATE AND MULTIVARIATE ANALYSES PREDICTING CHANGES IN CLINICAL OUTCOMES

Multivariate analysis showed that changes in diagnoses ($P=.01$), disease management ($P<.001$), and the num-

Table 2. Changes in Diagnosis and Disease Management

Variable	No. (%) of Cases (n=1490)
Diagnosis	
Change	1042 (69.9)
No change	448 (30.1)
Disease management, change overall	1455 (97.7)
Change in dosage or vehicle of medication	71 (4.8)
Initiation or discontinuation of medication	1006 (67.5)
Request of additional laboratory workup	272 (18.3)
Intervention, ie, biopsy	393 (26.4)

ber of teledermatology visits ($P<.001$) were significantly associated with improvement in clinical outcomes, after adjusting for age, sex, time to teledermatology consultation, and consultant diagnosis (**Table 3** and **Table 4**).

Specifically, patients with a change in diagnosis experienced a 1.97 increased odds (95% CI, 1.15-3.37) of clinical improvement, compared with patients whose diagnoses remained unchanged. Furthermore, each additional teledermatology follow-up visit was associated with 2.06 increased odds of experiencing improvement in clinical outcomes (95% CI, 1.44-2.95).

COMMENT

To our knowledge, this is the largest study to date that evaluated the clinical outcomes of LI teledermatology within an established telemedicine program. Although the number of S&F teledermatology programs has increased in the past 5 years, the number of LI teledermatology programs has remained relatively stable. Compared with S&F teledermatology, LI teledermatology programs possess unique challenges, such as increased cost of technology, varying video image quality, and operational efficiency issues. Potential operational efficiencies with LI teledermatology may arise from extra time necessary to switch among different referral sites, low bandwidth conferring unclear video images, or untrained camera operators. However, despite these potential challenges, because LI teledermatology enables real-time dialogue between the patients and the specialist, this modality most closely simulates in-person encounters.

The findings from this study corroborate those from previous telemedicine studies^{18,25,26} evaluating changes in clinical outcomes in dermatology, endocrinology, psychiatry, and pediatric weight management. Other investigations²³ have evaluated outcome measures and factors related to use of conventional vs teledermatology follow-up care subsequent to teledermatology evaluation; our study specifically evaluated the impact of LI teledermatology on patient care and clinical status. Nearly 70% of our patients experienced a change in diagnosis, and more than 97% of our patients experienced changes in disease management as a result of the teledermatologist evaluation.

These changes were significantly associated with improved clinical outcomes. Specifically, of the patients who

Table 3. Univariate Analysis of Variables Affecting Clinical Improvement^a

Variable	OR	SE	95% CI ^b	P Value
Age	1.02	1.00	1.00-1.04	.54
Female sex	1.04	0.30	0.59-1.82	.89
Time from referral to visit	0.98	0.02	0.95-1.01	.18
Diagnostic category	0.76	0.10	0.60-0.98	.03
Change in diagnosis	1.66	0.42	1.01-2.74	.045
No. of visits	1.93	0.33	1.38-2.70	<.001

Abbreviation: OR, odds ratio.

^aChange in disease management predicts clinical improvement perfectly.

^bData represent the 95% CIs of the ORs.

Table 4. Multivariate Analysis of Variables Affecting Clinical Improvement^a

Variable	OR	SE	95% CI ^b	P Value
Age	1.01	0.01	0.99-1.03	.55
Female sex	0.89	0.28	0.49-1.64	.72
Time from referral to visit	0.98	0.02	0.95-1.01	.20
Diagnostic category	0.79	0.11	0.60-1.02	.06
Change in diagnosis	1.97	0.54	1.16-3.37	.01
No. of visits	2.06	0.38	1.44-2.95	<.001

Abbreviations: OR, odds ratio; SE, standard error.

^aChange in disease management predicts clinical improvement perfectly.

^bData represent the 95% CIs of the ORs.

had 2 or more LI teledermatology visits, nearly 70% experienced clinical improvement. These findings suggest that LI teledermatology consultations likely resulted in improved diagnostic accuracy and more-effective treatment plans. The downstream impact of LI teledermatology may include reduced costs associated with additional visits or medications as well as improved primary care provider practice as a result of increased familiarity with dermatologic diagnoses and their associated management plans.²⁷

Our study also found that an increased number of follow-up teledermatology visits is significantly associated with clinical improvement. Close clinical monitoring and follow-up of patients through teledermatology consultations may be important for continued clinical improvement, especially for those with complex or chronic dermatologic conditions.

The results of our study must be interpreted within the context of the design. Because our program cares for an underserved population in California, including a sizable prison population, the demographic distribution of our data may not reflect the overall US population. Furthermore, because this was not a randomized controlled trial, it is difficult to assess the precise extent to which teledermatology consultations may affect clinical outcomes compared with management by primary care physicians alone in the same clinical setting.

Our study showed that LI teledermatology consultations resulted in changes in diagnosis and disease management in most consultations. Furthermore, the number of LI teledermatology visits and changes in diagnosis and disease management were significantly associated with improved clinical outcomes. With advancements in videoconferencing technology, interactive mobile plat-

forms, and connectivity speed, the practice of LI teledermatology will likely become more efficient and similar to in-person encounters in the near future. Continued research in clinical outcomes is necessary to ensure that this health care delivery modality is continually evaluated to deliver quality dermatologic care.

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