Evaluation of Patients Undergoing Removal of Glass Fragments From Hand Injuries

A Retrospective Study

Serdar Tuncer, MD, Ismail Bulent Ozcelik, MD,† Berkan Mersa, MD,† Fatih Kabakas, MD,† and Turker Ozkan, MD‡*

Abstract: The hand is the body part most frequently injured by broken glass. Glass fragments lodged in soft tissues may result in numerous complications, such as infection, delayed healing, persistent pain, and late injury as a result of migration. Between 2005 and 2010, we removed 46 glass particles from the hands of 26 patients. The injuries were caused for the following reasons: by car windows broken during motor vehicle accidents in 11 patients (42%); by fragments from broken glasses, dishes, or bottles in 9 (35%); by the hand passing through glass in 5 (19%); and by a fragment from a broken fluorescent lamp in 1 (4%) patient. Despite the efficacy of plain radiographs in detecting glass fragments, they are sometimes not obtained. Given the relatively low cost, accessibility, and efficacy of radiographs, and the adverse consequences of retained foreign bodies, the threshold for obtaining radiographs should be low in diagnosing glass-related injuries of the hand.

Key Words: glass injuries of the upper extremity, foreign bodies, glass fragments

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Glass injuries are frequent causes of referral to the emergency department, constituting 13% of all traumatic wounds.[1] Among 432 patients with glass-caused wounds, the hand was the most frequently injured body part, being involved in 35% of all injuries.[2] Fragments of broken glass may be lodged in soft tissues and result in numerous complications, such as infection, delayed healing, persistent pain, and late injury as a result of migration.[3–6] Foreign bodies retained in soft tissue are also a frequent source of litigation from emergency departments.[7] Therefore, essential for treating these injuries is the assurance that no glass remains in the wound before closure.[8]

Plain radiography is sensitive and specific for detecting glass fragments in the body, and it is accepted as the reference standard for this task.[2,9] The standard 2-view plain radiograph can detect 99% of glass shards that are greater than 2 mm.[10] Unfortunately, the widely held misconception that only leaded glass is radiopaque,[11] and therefore visible on plain radiographs, discourages their use in many such injuries.

However, the indications for obtaining radiographs in glass-related injuries are poorly defined. Numerous studies have investigated the patient and wound characteristics that increase the possibility of the presence of foreign bodies and the efficacy of visualizing the wound to exclude the presence of glass.[8,9,12] These studies have shown that negative wound exploration findings can reduce the possibility of the presence of foreign bodies but does not always rule out their presence. Most studies on glass fragments are conducted in emergency departments, and the literature on glass-inflicted hand injuries has focused more on the surgical treatment of underlying injuries. In this report, we describe our experience in surgically removing glass fragments from the hand and suggest ways to improve the diagnosis and management of these foreign bodies.

From the *Department of Plastic and Reconstructive Surgery, Istanbul Bilim University Medical Faculty, Istanbul, Turkey; †Ist-el Hand Surgery, Microsurgery and Rehabilitation Group, Istanbul, Turkey; and ‡Department of Orthopedics and Traumatology, Istanbul Bilim University Medical Faculty, Istanbul, Turkey.

Reprints: Serdar Tuncer, MD, Kocamansur Sok, Number 104/4, Zarif Apt, Sisli, Istanbul, Turkey. E-mail: serdartuncer@hotmail.com.

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PATIENTS AND METHODS

We have reviewed the medical records of the Hand and Microsurgery Unit of Gaziosmanpasa Hospital, a private hospital in Istanbul, Turkey, for patients presenting with glass-related injuries to the hand between June 2005 and January 2010. As a tertiary referral center for hand trauma, the Hand and Microsurgery Unit has about 800 emergency visits each year. Approximately 15% of these are glass-related injuries. The Hand and Microsurgery Unit is staffed by 3 physicians who treat all major hand and arm injuries referred to the unit. As a referral center for hand surgery, the unit is likely to see more severe injuries not usually treatable by local emergency physicians.

We also reviewed the records of the Istanbul Bilim University Hospital, an academic medical center, for similar patients presenting between 2008 and 2010. Bilim University Hospital has 2 hand surgeons who see about 100 emergency injuries to the hand each year. These injuries are more likely to come from the community than to be referrals from other medical care facilities.

RESULTS

During the study period, we removed 46 glass fragments from the hands of 26 (14 men) patients with a mean (standard deviation) age of 28 years (range: 15–52 years; Table 1). Of these, 18 patients were treated at the Hand and Microsurgery Unit of Gaziosmanpasa Hospital and 8 at Istanbul Bilim University Hospital.

The principle reason for presenting to the hand and microsurgery unit, reported by 25 (96%) patients, was the sensation of a foreign body or the presence of a subcutaneous mass. One patient presented 10 days after a traffic accident for multiple lacerations on the dorsal aspect of the hand. Three patients also had a local tissue reaction, seen as localized erythema, tenderness and induration of the surrounding skin in 2 patients, and increased pigmentation in 1. (Fig. 1). Physical examination revealed one or more subcutaneous foreign bodies in 12 patients.

The injuries were caused by car windows broken during motor vehicle accidents in 11 patients (42%); by fragments from broken glasses, dishes, or bottles in 9 (35%); by the hand passing through glass in 5 (19%); and by a fragment from a broken fluorescent lamp in 1 (4%) patient. On the basis of appearance of the wounds or scars, the injuries were classified as punctures (69%) or

TABLE 1. Characteristics of Patients Undergoing Removal of Glass Fragments Between 2005 and 2010 at the Hand and Microsurgery Unit of Gaziosmanpasa Hospital and Istanbul Bilim University Hospital, Istanbul, Turkey

				Fragments			
Gender	Age, yr	Wound Type	Cause of Injury	n	Size, mm	Location of Injury	Follow-up, mo
F	35	Puncture	Motor vehicle	7	2–8	Dorsal	2
M	23	Puncture	Motor vehicle	2	3–5	Dorsal	6
F	52	Puncture	Motor vehicle	1	3	Dorsal	3
F	20	Puncture	Motor vehicle	1	4	Dorsal	1
F	42	Puncture	Motor vehicle	3	2–5	Volar	3
M	16	Laceration	Motor vehicle	1	5	Volar	8
M	24	Puncture	Motor vehicle	2	3–6	Dorsal	6
M	15	Puncture	Motor vehicle	3	3–5	Dorsal	6
F	23	Puncture	Motor vehicle	1	5	Dorsal	3
M	48	Puncture	Motor vehicle	1	5	Dorsal	2
F	19	Puncture	Motor vehicle	4	4–6	Dorsal	24
M	17	Puncture	Plate glass	2	2–3	Volar	18
M	22	Puncture	Plate glass	1	3	Dorsal	4
M	22	Puncture	Plate glass	2	4–10	Dorsal	3
M	23	Puncture	Plate glass	2	5	Dorsal	12
M	32	Puncture	Plate glass	1	5	Volar	6
F	38	Laceration	Dish/drinking glass	1	5	Dorsal	2
F	20	Laceration	Dish/drinking glass	1	6	Volar	4
M	22	Puncture	Dish/drinking glass	2	2–5	Dorsal	3
F	30	Laceration	Dish/drinking glass	1	6	Volar	3
F	26	Puncture	Dish/drinking glass	1	4	Volar	8
M	30	Laceration	Dish/drinking glass	1	3	Volar	2
F	33	Laceration	Dish/drinking glass	1	3	Dorsal	8
M	32	Laceration	Dish/drinking glass	1	3	Dorsal	8
M	27	Puncture	Dish/drinking glass	1	5	Dorsal	4
F	44	Laceration	Light bulb	2	3–4	Volar	4

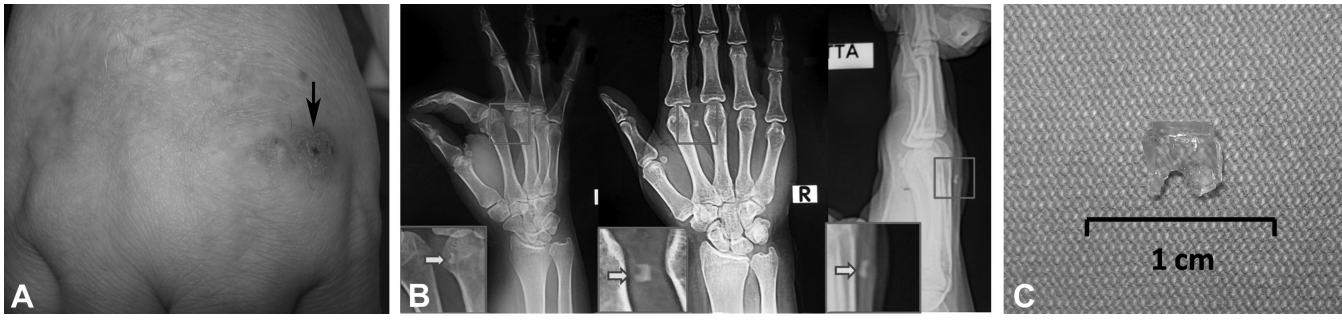

FIGURE 1. A 52-year-old-woman presented with a foreign body sensation on the dorsal aspect of her hand that appeared after a motor vehicle accident. A, Her hand showed multiple small scars and the signs of soft tissue reaction. B, A superficial foreign body between second and third metacarpal bones was visible on plain radiographs. C, The glass fragment.

lacerations (31%). Patients with both punctures and lacerations were classified as having puncture wounds.

The mean time between injury and presentation to the clinic was 66 days (range: 0–210 days). Of the 26 patients, 22 were initially treated by emergency physicians and the rest treated their own injuries at home. Three patients, 2 with tendon injuries and 1 with multiple fractures of the hand, had previously undergone surgery at the Hand and Microsurgery Unit and returned for problems related to foreign bodies remaining after the surgery. All other patients were either seen in an emergency department or had not received any treatment.

Two patients presented on the day of injury, 1 with a small puncture injury and 1 with a minor laceration (<1 cm) that had been sutured at another hospital. Six other patients presented within 10 days after the injury, and the wounds had been sutured in 2 of these. The remaining patients had only scars.

Initial treatment consisted of primary wound repair in 7 patients (27%), and healing by secondary intention in 19 (73%); 9

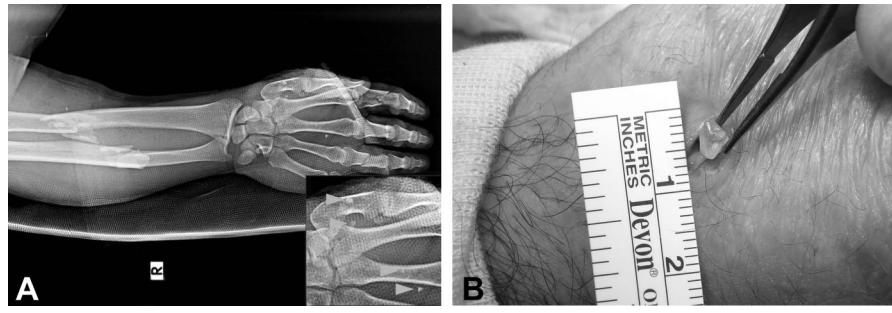

FIGURE 2. A, Initial radiograph of the hand of a 20-year-old man after a motor vehicle accident. The patient had been operated on 6 months earlier for multiple fractures and tendon injuries of the right arm. He later presented with a foreign body sensation on the dorsum of the hand between the first 2 metacarpals. Although the glass particles were visible in the initial radiographs they were overlooked in the first operation. B, The removal of the foreign body causing the symptoms.

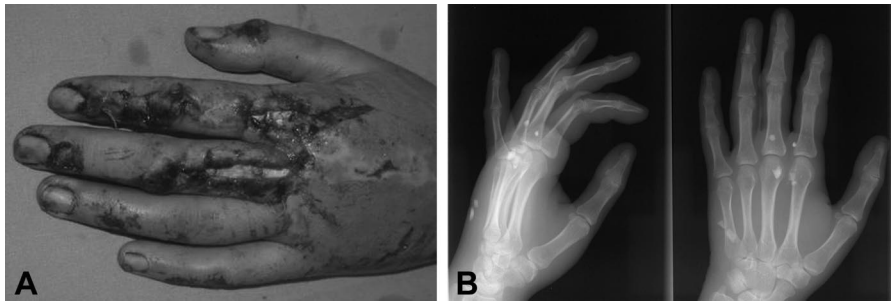

FIGURE 3. A, The left hand of a 35-year-old woman who had a motor vehicle accident 10 days before presenting with soft tissue injuries. B, Multiple glass fragments are visible on plain radiography; 7 foreign bodies were removed from this patient.

(35%) of the injuries were on the volar aspect of the hand and wrist, and 17 (65%) were on the dorsal aspect.

Radiographs were obtained to verify the presence of foreign bodies in 24 patients. Only 2 patients had radiographs from before the current injury: one patient had undergone surgery at our Unit for phalangeal and metacarpal fractures (Fig. 2), and the other had a severe dorsal injury of the hand (Fig. 3). The radiographs were positive for glass particles in all patients, with 2-way (anteroposterior and lateral) radiographs obtained for finger injuries, and 3-way (anteroposterior, lateral, and oblique) radiographs for hand and wrist injuries.

All fragments were removed in the operating room with the patient under local or regional anesthesia. A tourniquet was used, but not Esmarch bandage, to prevent iatrogenic injury by moving the fragments. Fluoroscopy was used during surgery in all patients, both to localize the particles and to ensure that all fragments had been removed.

We removed 46 glass fragments, or an average of about 2 fragments per patient (range: 1–7 fragments). The size of the fragments ranged between 0.2 and 1 cm (Table 1). Exploration of the surgical field did not reveal any additional injuries.

Mean follow-up was 5.6 months (range: 1–24 months). There were no postoperative infectious complications. Two patients reported residual pain and discomfort in the area of removal, but follow-up radiographs in these patients revealed no remaining foreign bodies. These 2 patients were not treated further. Soft-tissue, foreign-body reactions resolved in the 3 patients who presented with these signs; the remaining patients were free of symptoms with respect to foreign bodies.

DISCUSSION

Wounds cared for in the emergency departments are often considered to be "minor," if they do not require surgery in an operating room.[13] However, in a study of settled malpractice claims against emergency physicians in Massachusetts, wounds were the most common source of claims. Of the 109 claims, 32% involved retained foreign bodies, and another 34% were caused by allegedly undiagnosed injuries to tendons or nerves.[13]

Kaiser et al investigated the closed case records from the files of the Medical Professional Mutual Insurance Company involving claims of retained foreign bodies over a 7-year period.[14] The 54 claims were filed by 32 patients against 32 physicians; indemnity payments were approximately US $1.3 million. Glass was the most frequently retained foreign body, appearing in 29 (53%) of the claims. Radiographs were ordered only in 6 (35%) of these patients. Of the 11 cases in which glass fragments were retained when no radiologic study was obtained, 60% of the claims were lost by the physicians and had higher indemnity payments. Therefore, foreign body retention should be considered as a risk in all glass-related injuries.

In hand injuries, however, especially glass-related injuries, excluding the presence of glass fragments seems to be more important for most examiners than excluding underlying injuries.[15] The hand is a structure where even small lacerations have the potential to conceal underlying deep and important injuries.[16] Physical examination alone is insufficient for diagnosis. McNicholl et al showed that subclinical injuries were present in about half of the lacerations of the forearm and hand.[17] Therefore, we believe that adequate management of glass-related injuries of the hand should fulfill 2 equally important requirements: excluding foreign bodies and managing injuries to the underlying structures.

Almost all glass fragments can be detected radiographically because all glass (not just leaded glass!) is radio-opaque. High-resolution or mammographic techniques can detect particles even less than 2 mm.[18,19] The relative density of glass determines its radiopacity. All common modern glass has a relative density high enough (>2.0, with soft tissue being 1.0) to be detected on plain radiography.[3,20] The detection rate of radiography is limited by the

size of the fragment; in 1 study, the rate was 61% for 0.5-mm objects, 83% for 1-mm objects, and 99% for 2-mm objects.[10] The clinical importance of fragments smaller than 2 mm is unclear.[3] Also, the most common reason for missing foreign bodies in the hand is the failure to obtain a radiograph, rather than the sensitivity of the imaging modality.[21]

The strategy for treating penetrating trauma of the extremities, as outlined by the American College of Emergency Physicians, is that "if the suspicion for a foreign body is low and the entire depth and extent of the wound can be visualized, then additional imaging or exploration is not necessary."[22] Other imaging modalities may be indicated if there is a strong suspicion of a glass fragment, such as a nonhealing, infected, or persistently painful glass-related wound for which plain radiography is negative.[23] Given the high sensitivity and easy accessibility of plain radiographs, they should be used liberally when foreign bodies are suspected.

Patients with particular risk of foreign bodies are generally those with multiple puncture injuries.[12] Such injuries constituted 69% of injuries in our patient group. We believe that fragmentation of glass and penetration of the wound with multiple particles at high velocities may increase the risk of foreign bodies. All but one of our patients had fragments less than 1 cm long. We found few cases in the literature reporting larger glass foreign bodies.[3,4,6] However, considering the high variability of injuries by glass, determining which patients have a lower possibility of foreign bodies is difficult.

The most common mechanism of injury was motor vehicle accidents (42%). Most vehicles today have laminated windscreens that do not shatter because the glass fragments adhere to a layer of vinyl placed between the layers of glass. The side and rear windows are composed of tempered glass, which is designed to disintegrate into small pieces to avoid injuring passengers. However, injuries from these fragments still occur, and they can lodge in the tissues.

Numerous studies have investigated the value of routine radiography in assessing glass-related wounds. In a prospective study of 226 children with lacerations caused by glass, Avner and Baker investigated whether determining that the bottom of the wound was free of glass would eliminate the possibility that glass was present in the wound.[8] Of the 160 wounds (71%) in which the bottom of the wound was visualized and thought to be free of glass, routine radiographs detected the presence of glass in 11 (7%) patients. The authors stated that the policy of not obtaining radiographs for lacerations in which the bottom of the wound was thought to be free of glass would have avoided 149 unnecessary radiographs, but 11 lacerations would have been closed with retained glass fragments. In this same study, the sensitivity of radiographs for detecting glass fragments was 96%.

In a retrospective study, Montano et al reported that of 578 glass-related wounds, 48% were evaluated with "exploration or probing," 44% with irrigation, and 2% with palpation. There was no documentation of assessment for 61% of the cases.[2] Glass fragments were less likely to be retained in wounds of the hand and more likely to be retained in motor vehicle accidents and when stepping on glass. In addition, puncture wounds more often harbored glass than did lacerations. However, these findings were not adequate to clarify the indications for radiography, and the authors concluded that prospective studies were required.

In a prospective study, Steele et al identified injuries with a high risk of foreign bodies and tested the predictive value of a patient's foreign body sensation and of negative probing exploration of the wound for glass.[12] The positive predictive value of patient perception was 31%, and the negative predictive value was 89%. In 5 of 185 cases, wound exploration was negative but subsequent radiographs detected foreign bodies. However, in this study, wound exploration consisted of probing with a blunt clamp, and it is difficult to know whether a thorough exploration with visualization of the wound would yield the foreign body.

Orlinsky and Bright prospectively studied 264 wounds classified as superficial or deep.[9] Foreign bodies were not detected through physical examination in 2 (1.5%) of 134 superficial wounds and in 10 (7.7%) of 130 deep wounds. Given the benign nature of the 2 superficial wounds, the authors concluded that there is a subset of superficial and adequately explorable wounds that do not routinely require radiographs. The exploration method in their study consisted of probing and visual inspection of the wound.

Taken together, the results of these studies indicate that radiographs should be used liberally in glass injuries of the hand and that the threshold for obtaining a radiograph should be low.

Differences in the method of surgical exploration of the wound between studies make evaluating the efficacy of clinical examination difficult. Given the possibility of tendon and nerve lacerations in the hand, we do not advocate blunt probing of hand injuries. In our opinion, the appropriate approach to all glass-caused wounds should include adequate anesthesia, a bloodless field, retracting the wound, spreading the deeper tissues for an extensive visualization, extending skin laceration where necessary, and finally irrigating the tissues. Jet irrigation of the wound with a syringe is helpful in removing embedded fragments. However, without a prospective study, it cannot be determined whether all glass foreign bodies in the hand would have been retrieved during exploration.

Three of the patients in our series had been previously operated on by our team, 2 for tendon injuries and 1 for fractures of the arm. One of these patients had an extensor tendon injury in which only skin closure had been performed, by another emergency department. During tendon repair, we explored the wound but later retrieved foreign bodies from outside the area of exploration. The second patient had glass injuries in both hands, and the foreign body was not in the hand operated on for tendon injury. The wound was superficial and appeared benign and so was not explored. These foreign bodies could have been retrieved during the initial operation if radiographs had been obtained for all glass-related injuries. In the patient with fractures, the glass fragments were evident in the initial radiographs but had been overlooked among multiple fractures.

These cases have influenced our daily practice as a hand surgery unit. We greatly increased the use of radiography in glass injuries of the arm and hand. The increased costs and radiation exposure of routine radiographs must be weighed against the consequences of missing foreign bodies.

The decision to remove a foreign body or not should be based on the nature and size of the foreign body, its anatomic location, the degree of wound contamination, the presence of symptoms or the anticipation that symptoms will be produced, and the actual or potential loss of function.[24] Foreign bodies adjacent to important anatomic structures, such as tendons, nerves, or vessels should be removed because of the potential for mechanical injury to these structures during motion. Those foreign bodies that are asymptomatic, inert, and do not interfere with function, or are so small that localization and removal would be difficult, should be left alone.[25]

None of the studies in the literature discusses the use of radiography after foreign body removal. Although we do not believe that radiographs are always necessary, they may be useful in patients with multiple glass fragments or in circumstances where either the doctor or the patient is not sure that all fragments have been removed. We have found the use of an image intensifier very helpful during removal.[21]

Limitations of the Study

The retrospective nature of this study is a limitation because we cannot guarantee complete data capture. Radiographs were not routinely acquired for these injuries, especially during the early

phases of the study period, and so only some of the patients with such injuries had radiographs taken. A prospective study that uses routine radiography, the current reference standard for ruling out the presence of glass, may provide information on the incidence of and the risk factors for glass foreign bodies in hand injuries.

CONCLUSIONS

Removing foreign bodies in hand injuries caused by glass is as important as the diagnosis and repair of the underlying injuries. Glass fragments are best managed in acute-care settings. The index of suspicion for glass fragments in injuries of the arm and hand should be low, and when suspicion is raised, plain radiographs should be obtained. Puncture wounds have a greater possibility of retaining glass fragments. Given the high sensitivity of plain radiography in detecting glass fragments, the most important reason for missing glass foreign bodies is the failure to obtain radiographs. However, prospective, blinded studies are required to establish the routine use of radiography in managing hand injuries caused by glass.

REFERENCES

1. Hollander JE, Singer AJ, Valentine S, et al. Wound registry: development and validation. *Ann Emerg Med*. 1995;25:675–685.
2. Montano J, Steele M, Watson W. Foreign body retention in glass caused wounds. *Ann Emerg Med*. 1992;21:1360–1363.
3. Opel DJ, Lundin DA, Stevenson KL, et al. Glass foreign body in the spinal canal of a child: case report and review of the literature. *Pediatr Emerg Care*. 2004;20:468–472.
4. Browett JP, Fiddian NJ. Delayed median nerve injury due to retained glass fragment: a report of two cases. *J Bone Joint Surg Br*. 1985;67:382–384.
5. Yang SS, Bear BJ, Weiland AJ. Rupture of the flexor pollicis longus tendon after 30 years due to migration of a retained foreign body. *J Hand Surg Br*. 1995;20:803–805.
6. Meurer WJ. Radial artery pseudoaneurysm caused by occult retained glass from a hand laceration. *Pediatr Emerg Care*. 2009;25:255–257.
7. Vukmir RB. Medical malpractice: managing the risk. *Med Law*. 2004;23: 205–231.
8. Avner JR, Baker MD. Lacerations involving glass. The role of routine roentgenograms. *Am J Dis Child*. 1992;146:600–602.
9. Orlinsky M, Bright AA. The utility of routine x-rays in all glass-caused wounds. *Am J Emerg Med*. 2006;24:233–236.
10. Courter BJ. Radiographic screening for glass foreign bodies—what does a "negative" foreign body series really mean? *Ann Emerg Med*. 1990;19:997–1000.
11. Klein KA, Hobbs BB. Radio-opacity of glass: does the lead content matter? [abstract].*CMAJ*. 1995;153:1224.
12. Steele MT, Tran LV, Watson WA, et al. Retained glass foreign bodies in wounds: predictive value of wound characteristics, patient perception, and wound exploration. *Am J Emerg Med*. 1998;16:627–630.
13. Trott AT. Emergency wound care: an overview. In: Trott AT. *Wounds and Lacerations: Emergency Care and Closure*. 3rd ed. Philadelphia, PA: Elsevier Mosby; 2005:1–2.
14. Kaiser CW, Slowick T, Spurling KP, et al. Retained foreign bodies. *J Trauma*. 1997;43:107–111.
15. Guly HR. Missed tendon injuries. *Arch Emerg Med*. 1991;8:87–91.
16. Tuncali D, Yavuz N, Terzioglu A, et al. The rate of upper extremity deep structure injuries through small penetrating lacerations. *Ann Plast Surg*. 2005;55:146–148.
17. McNicholl BP, Martin J, McAleese P. Subclinical injuries in lacerations to the forearm and hand. *Br J Surg*. 1992;79:765–767.
18. Grøn P, Andersen K, Vraa A. Detection of glass foreign bodies by radiography. *Injury*. 1986;17:404–406.
19. de Lacey G, Evans R, Sandin B. Penetrating injuries: how easy is it to see glass (and plastic) on radiographs? *Br J Radiol*. 1985;58:27–30.
20. O'Driscoll SW. Glass is detectable on plain radiographs. *CMAJ*. 1988;139: 643–644.
21. Anderson MA, Newmeyer WL III, Kilgore ES Jr. Diagnosis and treatment of retained foreign bodies in the hand. *Am J Surg*. 1982;144:63–67.
22. American College of Emergency Physicians. Clinical policy for the initial approach to patients presenting with penetrating extremity trauma. *Ann Emerg Med*. 1999;33:612–636.
23. Humphrey G, Super P, Dalton M, et al. Retained glass foreign bodies: confirmation and localization by computerized tomography and ultrasonography. *Injury*. 1993;24:493–494.
24. Smoot EC, Robson MC. Acute management of foreign body injuries of the hand. *Ann Emerg Med*. 1983;12:434–436.
25. Stein F. Foreign body injuries of the hand. *Emerg Med Clin North Am*. 1985;3:383–390.