

Removal Time and Efficacy of Riddell Quick Release Face Guard Attachment System Side Clips During 1 Football Season

Tonia Gruppen, MS, ATC; Molly Smith, BA, ATC; Andrea Ganss, MS, ATC

Hope College, Holland, MI. Ms Smith is now at the University of North Carolina, Chapel Hill. Mrs Ganss is now at Detroit Medical Center Rehabilitation Institute of Michigan, West Bloomfield.

Context: In the National Athletic Trainers' Association position statement, "Acute Management of the Cervical Spine-Injured Athlete," the technique recommended for face-mask (FM) removal is one that "creates the least head and neck motion, is performed most quickly, is the least difficult, and carries the least chance of failure." Industrial and technological advances in football helmet design and FM attachment systems might influence the efficacy of emergency FM removal.

Objective: To examine the removal times and success rates of the Quick Release (QR) Face Guard Attachment System (Riddell Sports, Inc, Elyria, OH) throughout and at the conclusion of 1 season of play by a National Collegiate Athletic Association Division III football team competing in the Midwest.

Design: Controlled laboratory study.

Setting: College laboratory.

Patients or Other Participants: A total of 69 randomly selected Revolution IQ (Riddell Sports, Inc) football helmets fitted with the QR system were used.

Intervention(s): Each helmet was secured to a spine board, and investigators attempted to remove both of the QR side clips from the helmet with the Riddell insertion tool.

Main Outcome Measure(s): Dependent variables included total time for removal of both QR side clips from the FM and success rate for removal of both side clips.

Results: The overall success rate for removal of both clips was 94.8% (164/173), whereas the mean times for removal of both clips ranged from 9.92 ± 12.06 seconds to 16.65 ± 20.97 seconds over 4 trial sessions. We found no differences among mean times for trial sessions throughout the season of play among the same helmets or among different helmets ($P > .05$).

Conclusions: Removal time and success rate of the Riddell QR were satisfactory during and after 1 season of play despite use in various temperatures and precipitation.

Key Words: protective equipment, football injuries, cervical spine, airway management, emergency management

Key Points

- The success rate for removing the individual side clips of helmets fitted with the Riddell Quick Release (QR) Face Guard Attachment System and worn during 1 season of play was 97.4%.
- Times were not different for removing the QR side clips among the same helmets tested throughout the season or for removing the side clips between helmets initially tested at different times in the season.
- The QR system facilitated a satisfactory method of face-mask removal; however, athletic trainers should have the proper backup tool available to remove the face mask, and they should use the pocket-mask insertion method or remove the helmet and shoulder pads to gain access quickly to the airway if the side clips cannot be removed.

Management of a suspected cervical spine injury in a football player is one of the most critical situations that a certified athletic trainer can encounter. This type of injury can involve respiratory compromise, requiring quick airway access through removing the face mask (FM) from the football helmet. Minimizing head and neck movement during FM removal also is imperative because excessive movement can increase the severity of spinal injuries.^{1–4}

The current standard of practice in managing a football athlete with a possible spinal cord injury was established in the National Athletic Trainers' Association (NATA) position statement, "Acute Management of the Cervical Spine-Injured Athlete."⁵ The Inter-Association Task Force for Appropriate Care of the Spine-Injured Athlete⁶ previously provided guidelines for the management of such injuries. In the NATA⁵ position statement, the

technique recommended for removing a FM "creates the least head and neck motion, is performed most quickly, is the least difficult, and carries the least chance of failure." The Inter-Association Task Force for Appropriate Care of the Spine-Injured Athlete⁶ recommended leaving the football player's helmet in place but removing the FM from the helmet "as quickly as possible and with as little movement of the head and neck as possible." Researchers have determined that the combined-tool approach of the cordless screwdriver as the primary removal tool and a cutting tool as the secondary tool provides a fast, reliable means of on-field FM removal.^{7–9}

Recent technological developments in football helmet design have led to changes in traditional football helmets, including the FM attachment system. Specifically, the recent modifications in the Revolution IQ (Riddell Sports, Inc, Elyria, OH) football helmet include a quick-release FM

attachment system. The Riddell Quick Release (QR) Face Guard Attachment System (Riddell Sports, Inc) is used to attach the 2 side clips, whereas the top 2 loop straps are attached with the traditional screw and T-nut design. Researchers studying the QR side clips have shown the average time to remove the FM is faster and the resultant head motion are less than those with a traditional FM attachment system.^{10,11}

Research on the QR system is limited and mostly has been conducted on new football equipment. To our knowledge, authors of only 1 other study¹² have investigated QR side clips on equipment that has been used during football participation. A season of play might affect football equipment due to factors associated with weather, multiple impacts, and playing surfaces. These conditions also might cause difficulties with removal of the FM with the QR side clips. Therefore, the purpose of our study was to examine the removal times and success rates of the QR system during and at the conclusion of 1 season of play by a midwestern collegiate football team participating at the National Collegiate Athletic Association Division III level. We developed 2 research hypotheses to guide the statistical approach: (1) frequency of QR side-clip removal failures and the mean times to complete QR side-clip removal would increase as the season progressed, and (2) frequency of QR side-clip removal failures and the mean times to complete QR side-clip removal would be greater at the end of the season than at preseason.

METHODS

We collected data on a selection of Revolution IQ football helmets used by a Division III football team throughout the season. For the season of play, an equipment manager fitted each football player with an appropriate helmet, which was either a Revolution IQ or another model, based on size availability, number of helmets in the inventory, and the athlete's preference. Each Revolution IQ helmet was retrofitted with the QR side clips during the reconditioning process or by the manufacturer if the helmet was a new purchase. A total of 163 football players began the season, and 128 Revolution IQ helmets were available and fitted to players. The remaining players were fitted with other helmet models.

The football team participated in most of their practices and games on a natural grass surface. Only 1 practice of the season was conducted on a field turf surface rather than on natural grass. Seven of the team's games were played on natural grass, whereas the remaining 3 were played on field turf. This team from the Midwest played in various weather conditions, including differing amounts of sun, wind, and rain, throughout the season. The beginning of the season, which started August 12, was played in hot and humid conditions, and the last game of the season, which was on November 22, was played in accumulating snow. Daily weather conditions were not specifically tracked for the purpose of this study.

Data collection was conducted 4 separate times in a climate-controlled environment on the campus of the Division III institution. Two senior-level athletic training students (M.S., A.G.) performed the techniques of the QR side-clip removal in a similar manner on every tested helmet regardless of having different hand dominance



Figure 1. Quick Release Face Guard Attachment System (Riddell Sports, Inc, Elyria, OH) side clip attaches the face mask to the Revolution IQ (Riddell Sports, Inc) football helmet.

(Figure 1). Each performed approximately the same number of removal trials. Before the initiation of data collection, each investigator practiced removal of the QR side clips repeatedly until she was familiar and comfortable with the technique. This was done to eliminate learning effects as a possible confounding influence.

Instrumentation

The insertion tool (part 27515; Riddell Sports, Inc) was used to remove the QR side clips (Figure 2). A standard spine board (model 685; Ferno-Washington, Inc, Wilmington, OH) with attached foam blocks was used to securely hold the helmet in place and mimic in-line stabilization during each testing trial (Figure 3). A digital stopwatch (model S2XLO; Accusplit, Livermore, CA) was used to time all removal trials.

Procedures

Each helmet involved in our study was assigned to a testing group (A, B, C, or D) and might have undergone a different number of testing trials (range, 1 to 4 trials) according to this assignment. Helmets in group A were tested 4 times; helmets in group B, 3 times; helmets in group C, 2 times; and helmets in group D, 1 time.

For data collection, a baseline group (group A) of 40 randomly selected Revolution IQ helmets had the QR side



Figure 2. Riddell insertion tool (part 27515; Riddell Sports, Inc, Elyria, OH).



Figure 3. Helmet secured to a spine board (Ferno-Washington, Inc, Wilmington, OH) with foam blocks and straps for the testing procedure.

clips tested before the start of the season. The helmets themselves were either new or recently reconditioned; the QR side clips were fitted by the manufacturer, if the helmets were new, or by the reconditioner, if not new. The exact ratio of new to used helmets was not recorded. These helmets were selected indiscriminately from a storeroom before being assigned to players. For each subsequent testing session, 10 additional randomly selected helmets were picked from the players' lockers in the locker room. To be included, the helmet had to be a Revolution IQ fitted with the QR side clips. The player's name, position, and playing time were not considered. The testing session occurred at least 90 minutes after the conclusion of practice. If the helmet was dirty, no attempt was made to clean it for testing purposes. After selection, each helmet was labeled with a specific number for data-collection purposes. This was done as a means of identifying the helmet separately from the player's name and number. After 4 weeks (mid-September), 28 helmets in group A were retested, and 10 additional helmets (group B) were randomly selected for testing; however, only 9 of the 10 helmets in group B were tested. In mid-October, 25 helmets in group A were tested for the third time, 9 helmets in group B were tested for the second time, and an additional 10 helmets (group C) were selected and tested for the first time. For the final testing session in mid-November, 23 helmets in group A were tested for the fourth time, 9 helmets in group B were tested for the third time, 10 helmets in group C were tested for the second time, and an additional 10 helmets (group D) were selected and tested for the first time.

The 18 helmets that were either not tested or not retested had been removed from data collection as soon as the players sustained a season-ending injury or quit the team ($n = 17$) or the shell of the helmet became cracked and was deemed unsafe for the player to use ($n = 1$). A total of 173 trials, where 1 trial equaled attempted removal of both side clips, were conducted over the 4-month season and included helmets from groups A, B, C, and D.

We chose this sampling technique to allow for data

collection and analysis of the removal of QR side clips on the same helmet 4 times throughout the season (group A) and to analyze removal of QR side clips that had not been removed, except for a possible FM style change, until subsequent testing sessions (groups B, C, and D). The aim was to answer the question "Will a clip that has had minimal attention or maintenance throughout the season be removed as successfully in November as the clips initially removed in August?"

For each QR side-clip removal trial, the helmet was placed and secured to a spine board with foam blocks and straps. Investigator 1 began removing the QR side clips starting with the left side, then proceeding to the right side of the helmet with the insertion tool. Investigator 2 began timing when investigator 1 picked up the insertion tool and stopped when the investigator said, "Done," indicating that both clips had been removed successfully. To reduce the effects of fatigue, the investigators rotated after every 5 trials. Success and total time for removal of both QR side clips were recorded for each trial. A trial was classified as a *success* if both QR side clips were removed within 2 minutes. The trial was classified as a *failure* if both QR side clips were not removed within this time. The use of the 2-minute time limit was a modification of the 4-minute time limit for FM removal used in previous research.^{8,13} The time limit for the trial in our study was reduced to 2 minutes because after successful removal of the QR side clips, the top 2 loop straps would have to be removed by traditional methods, such as a cordless screwdriver or a cutting tool, to allow for complete FM removal. An investigator reapplied the side clips after the helmet was tested. If the trial was deemed a failure, the investigator continued to work to remove the side clips without being timed.

Throughout the season, maintenance occurred as needed for issues such as FM style changes per an athlete's request, but no regular maintenance on the helmets took place. No effort was made to determine each helmet's actual exposure time or player's position. Helmets that were no longer used by players due to season-ending injuries or their choice to quit the team were removed from the study.

Table 1. Success and Failure Rates for Removing Both Quick Release Face Guard Attachment System^a Side Clips

Group	Trial 1	Trial 2	Trial 3	Trial 4	Combined Totals
A					
Success, n (%)	36 (90)	28 (100)	25 (100)	22 (95.7)	111 (95.7)
Failure, n (%)	4 (10)	0 (0)	0 (0)	1 (4.3)	5 (4.3)
Total no. of helmets	40	28	25	23	116
B					
Success, n (%)	NA	9 (100)	9 (100)	9 (100)	27 (100)
Failure, n (%)	NA	0 (0)	0 (0)	0 (0)	0 (0)
Total no. of helmets	NA	9	9	9	27
C					
Success, n (%)	NA	NA	9 (90)	10 (100)	19 (95)
Failure, n (%)	NA	NA	1 (10)	0 (0)	1 (5)
Total no. of helmets	NA	NA	10	10	20
D					
Success, n (%)	NA	NA	NA	7 (70)	7 (70)
Failure, n (%)	NA	NA	NA	3 (30)	3 (30)
Total no. of helmets	NA	NA	NA	10	10
Total					
Success, n (%)	36 (90)	37 (100)	43 (97.7)	48 (92.3)	164 (94.8)
Failure, n (%)	4 (10)	0 (0)	1 (2.3)	4 (7.7)	9 (5.2)
Total no. of helmets	40	37	44	52	173

Abbreviation: NA, not applicable.

^a Riddell Sports, Inc, Elyria, OH.

Statistical Analysis

Independent variables included the testing group to which the helmet was assigned and the testing trial that each helmet underwent. Dependent variables included success or failure of QR side-clip removal and time for QR side-clip removal. Descriptive analyses were performed to report the frequencies and percentages of the number of failed trials of QR side-clip removal. We planned to perform a 1-way analysis of variance (ANOVA) to test for differences among failed trials with respect to the timing of the first removal. Means and standard deviations were calculated for the removal time for each testing session. An ANOVA was used to compare the mean time for QR side-clip removal for the same helmet over 4 testing sessions (group A). Two-sample independent *t* tests were used to compare mean times for QR side-clip removal for different helmets initially tested during different testing sessions throughout the season of play. We compared mean QR side-clip removal times for helmets in group A trial 1 with group B trial 2, group C trial 3, and group D trial 4; group B trial 2 with group C trial 3, and group D trial 4; and group C trial 3 with group D trial 4. The mean removal times for each investigator for each of the 4 testing sessions were compared with a 2-sample independent *t* test. The α level was set at .05 for all tests. We used SPSS (version 15.0; SPSS Inc, Chicago, IL) for data analysis.

RESULTS

The research design called for 220 QR side-clip removal trials throughout the 4-month period. However, 173 QR side-clip removal trials occurred throughout this period as a result of helmet disqualification due to season-ending injuries of players, players quitting the team, or damage to the helmet.

The success rate of removing both side clips was 94.8% (164/173), whereas the success rates of removing both side clips for testing sessions 1, 2, 3, and 4 were 90% (36/40),

100% (37/37), 97.7% (43/44), and 92.3% (48/52), respectively (Table 1).

Overall, we attempted to remove 346 side clips from 69 helmets during 173 removal trials. Nine side clips could not be removed in less than 2 minutes. All 9 removal failures occurred as a result of mechanism malfunction. This created a side-clip failure rate of 2.6% (9/346). Of the 9 failures to remove both side clips in 2 minutes, 8 occurred during the first documented removal trial of those specific helmets, and 1 occurred during the fourth removal trial of that specific helmet. In each instance, only 1 of the 2 side clips failed. No QR side clips failed in more than 1 testing session. After a side clip was deemed a failure for that testing session, we successfully removed the side clip and returned it to the helmet. The helmet then was returned to normal wear by a player. Further planned analysis to test for differences among failed trials with respect to timing of the first removal was not considered appropriate due to the small number of clip failures.

In addition to success rates of removing QR side clips, we documented and analyzed the side-clip removal times. The mean QR side-clip removal times for each group and each testing trial are provided in Table 2. The ANOVA results indicated no differences in mean QR side-clip removal time on the same helmets throughout the course of the season ($F_{3,18} = 0.507$, $P = .68$). The independent *t* test results indicated no differences in mean QR side-clip removal time of helmets initially tested at different times of the season ($t = -0.459$ to 0.751 , $P > .05$). The 2-sample independent *t* test showed no difference for mean removal times for each investigator for each of the 4 testing sessions ($t_{34} = -0.804$, $P = .43$).

DISCUSSION

The primary objective of this investigation was to examine the success rate and removal times of the Riddell QR Face Guard Attachment System during the course of 1 football season. We suspected that the time and failure rate

Table 2. Removal Times for Successful Removals of Both Quick Release Face Guard Attachment System^a Side Clips (Mean $\pm$ SD)

Group	Trial 1	Trial 2	Trial 3	Trial 4
A				
Mean $\pm$ SD, s	16.65 $\pm$ 20.97	13.63 $\pm$ 15.00	14.45 $\pm$ 24.31	9.42 $\pm$ 13.21
No. of helmets	36	28	25	22
B				
Mean $\pm$ SD, s	NA	11.78 $\pm$ 16.43	8.28 $\pm$ 5.80	9.28 $\pm$ 5.14
No. of helmets	NA	9	9	9
C				
Mean $\pm$ SD, s	NA	NA	13.21 $\pm$ 17.30	7.25 $\pm$ 3.97
No. of helmets	NA	NA	9	10
D				
Mean $\pm$ SD, s	NA	NA	NA	16.09 $\pm$ 20.22
No. of helmets	NA	NA	NA	7
Total				
Mean $\pm$ SD, s	16.65 $\pm$ 20.97	13.19 $\pm$ 15.14	12.90 $\pm$ 20.18	9.92 $\pm$ 12.05
No. of helmets	36	37	43	48

Abbreviation: NA, not applicable.

^a Riddell Sports, Inc, Elyria, OH.

of the QR side-clip removal would increase over the course of the football season as the helmets were exposed to the environment and the daily wear and tear associated with collegiate football. We also suspected that the time and failure rate of removing the QR side clips would be greater at the end of the season than at preseason. Our results did not support these hypotheses; therefore, we rejected them. The relatively small sample size prevented us from drawing strong conclusions about the effect of a season of play on the success of removing the QR side clips, and a larger sample might have revealed different results. However, the lack of a change in removal times over the season was an important finding. Clinicians can use this information to help understand the consistent capacity of the QR side clips to be removed.

Our results regarding removal of the QR side clips are difficult to compare directly with those reported in previous studies because the QR is a newer technological development that has been tested only in a few recently published FM-removal studies.^{10–12,14} Another challenging factor for comparison was that during collection, we removed only the 2 QR side clips and not the entire FM. Consequently, comparing our total times of removal (QR side clips only) with times reported in more recent studies is difficult because these researchers have reported total time of FM removal (all 4 loop straps removed). In their studies involving removal of QR side clips, Swartz et al¹⁰ reported a mean time of total FM removal (QR side clips and traditional front clips) of 33.96 $\pm$ 14.4 seconds, and Toler et al¹¹ reported that the mean time of total FM removal and subsequent pocket-mask placement over the airway was 50.37 $\pm$ 13.13 seconds. However, we have found times documented by investigators examining FM retraction (side loop straps removed and FM swung away using the top 2 loop straps as a hinge) to be comparable because the authors measured the times of just the side loop-strap removal.^{15,16} Our mean times for QR removal ranged from 9.92 $\pm$ 12.06 seconds to 16.65 $\pm$ 20.97 seconds over the 4 testing periods. The lower range of these results are comparable with preliminary findings of Swartz et al,¹⁴ in which they reported an average “split” time (time to remove the QR loop straps only) of 7.66 $\pm$ 1.67 seconds. Our results for time for removal of the QR side clips are

more favorable than those reported in previous research involving FM retraction with different tools. Jenkins et al¹⁵ reported mean times for FM retraction of 98.6 $\pm$ 50.5 seconds for the Trainer’s Angel (Trainer’s Angel, Riverside, CA), 71.74 $\pm$ 28.8 seconds for the FM Extractor (Sports Medicine Concepts, Geneseo, NY), and 34.1 $\pm$ 7.9 seconds for the power screwdriver. Ray et al¹⁶ reported mean times for retraction of the FM as 26.8 $\pm$ 4.5 seconds for the power screwdriver, 27.9 $\pm$ 3.0 seconds for the manual screwdriver, and 25.3 $\pm$ 4.6 seconds for the Trainer’s Angel. The composition of the samples in those studies was different from those in our study. In each of these studies, 1 football helmet was used for measurements, and the loop straps and hardware were replaced between trials. In addition, these researchers did not test helmets that were being used by football players throughout a season of play, which we believe is clinically important.

Regardless of tool, technique, or approach, the success rate for removing an FM attachment system is a vital part of our research. With the insertion tool, our success rate of removing both QR side clips from 1 helmet was 94.8% (164/173). This is difficult to compare with previous research because we measured a successful trial as removal of the 2 QR side clips and most other researchers have measured a successful trial as removal of all 4 loop straps for FM removal. Conversely, we easily can compare the per-clip removal success rate between our study and others that involved full FM removal with various removal tools. Overall, 337 of 346 (97.4%) QR side clips tested were removed successfully. This success rate is lower than that found by Swartz et al,¹⁰ who reported the intact QR side-clip removal rate was 100% in a laboratory setting on unused equipment. This success rate is also slightly higher than that found by Swartz et al,¹⁷ who used a cordless screwdriver for FM removal and demonstrated a per-screw successful removal rate of 94% (9673/10 284). Similarly, Decoster et al⁷ demonstrated a per-screw successful removal rate of 94% (832/885) with use of the cordless screwdriver for FM removal. In research involving a combined-tool approach with the cordless screwdriver as the primary tool and a cutting tool as the backup tool, Gale et al⁸ had a per-screw successful removal rate of 99.6% (303/304). In their research using a combined-tool

approach, Copeland et al⁹ had a per-screw successful removal rate of 100% (1200/1200).

Although the successful removal rate of the QR side clips tested in our study was comparable with rates reported in previous studies, we did encounter QR side clips that could not be removed in the allotted time. We believe that these failures occurred as a result of mechanism malfunction. We also believe that the mechanism contributed to the high standard deviations of mean removal times in this research. We eventually removed all failed side clips by continuously trying after the 2-minute time limit ended.

Given the current design associated with the Revolution IQ, the QR side clips are used only near the ear holes of the helmet, whereas traditional loop straps are used to fasten the top of the FM. Consequently, in accordance with previous research,⁷⁻⁹ we recommend the removal of the top loop straps with a cordless screwdriver as the primary tool and a backup cutting tool as needed. If a QR side clip cannot be removed due to mechanism malfunction, it can be removed with a backup cutting tool as shown by Swartz et al,¹⁰ who reported it presented a considerable challenge. If an athletic trainer cannot remove the QR side clip in a timely manner with either the insertion tool or a backup cutting tool, we recommend inserting a cardiopulmonary resuscitation pocket mask into the FM to initiate airway access. Ray et al^{16,18} and Toler et al¹¹ demonstrated this technique is effective. If the airway cannot be accessed through FM removal or pocket-mask insertion in a reasonable time, then the helmet and shoulder pads should be removed to ensure access to the athlete's airway as recommended by the NATA⁵ and the Inter-Association Task Force for Appropriate Care of the Spine-Injured Athlete.⁶

A clear limitation of this study lies in the small sample size and the consequential lack of generalization to settings other than a Division III college football team playing in the Midwest. Another potential limitation of this study involves our experimental setup. We mounted the helmet to a spine board rather than having a participant wear both the helmet and shoulder pads. As suggested by Swartz et al,¹³ the close proximity of the properly fitted shoulder pads to the helmet when worn by an actual participant could interfere with removal of side clips from the Revolution IQ by hindering proper tool placement. This might have influenced our removal times and success rates. The lack of geographic and environmental diversity of the helmets studied was also a limitation. Helmets from other regions of the country could be exposed to ranges in temperature and elements unlike those that we researched. For example, helmets used by teams in the coastal regions could be exposed to salty air that could cause corrosion of the hardware. We believe we had a wide range of temperatures and weather elements during the season of play of this Midwestern school. Conditions ranged from high humidity, high temperatures, and rain in the preseason to freezing temperatures and snow by the end of the season.

CONCLUSIONS AND RECOMMENDATIONS

Our results revealed a 97.4% side-clip removal success rate for the Revolution IQ helmets fitted with the QR side clips and worn for a full season of play by Division III collegiate football players. Testing trials throughout the

season revealed no difference in removal times of QR side clips among the same helmets tested throughout the season of play (group A). Trials also showed no difference in removal times between helmets initially tested at different times of the season (groups B, C, and D).

Based on these laboratory findings and other research involving the QR side clips, we believe that the Riddell QR system facilitates a satisfactory method of FM removal. Given the current design by Riddell, the 2 loop straps on the top of the FM remain the traditional design. With this understood, we recommend removal of these loop straps with a cordless screwdriver and a backup cutting tool if needed as demonstrated in previous research. If the QR side clips cannot be removed with a removal tool, we recommend using a backup cutting tool.¹⁰ Because the QR side clips cannot be cut with all tools, the athletic trainer should be sure to have the proper tool on hand. If the QR side clips still cannot be removed, we recommend the athletic trainer use the pocket-mask insertion method^{11,16,18} or helmet and shoulder-pad removal to gain access to the airway in a timely manner.^{5,6} Furthermore, we recommend an athletic trainer rehearse and practice FM removal with the tools and equipment that he or she might encounter.

Future researchers could repeat the methods of this study, measuring the time needed to completely remove the FM of a helmet using the QR side clips. Researchers also could conduct a similar study with participants wearing shoulder pads and helmets in an on-field environment to better simulate a football player with a suspected cervical spine injury. Future investigations could be conducted on the movement associated with FM removal involving the QR side clips. Finally, the relatively small and uniform sample size of this study means that research with larger, more diverse sample sizes is needed.

ACKNOWLEDGMENTS

We thank Kirk Brumels, PhD, ATC, for his insight into the conception and design. We also thank Jill VanderStoep, MS, for contributing to the conception and design and the analysis and interpretation of the data.

REFERENCES

1. Palumbo MA, Hulstyn MJ, Fadale PD, O'Brien T, Shall L. The effect of protective football equipment on alignment of the injured cervical spine: radiographic analysis in a cadaveric model. *Am J Sports Med.* 1996;24(4):446-453.
2. Gastel JA, Palumbo MA, Hulstyn MJ, Fadale PD, Lucas P. Emergency removal of football equipment: a cadaveric cervical spine injury model. *Ann Emerg Med.* 1998;32(4):411-417.
3. Swenson TM, Laueran WC, Blanc RO, Donaldson WR III, Fu FH. Cervical spine alignment in the immobilized football player: radiographic analysis before and after helmet removal. *Am J Sports Med.* 1997;25(2):226-230.
4. Prinsen RK, Syrotaik DG, Reid DC. Position of the cervical vertebrae during helmet removal and cervical collar application in football and hockey. *Clin J Sport Med.* 1995;5(3):155-161.
5. Swartz EE, Boden BP, Courson RW, et al. National Athletic Trainers' Association position statement: acute management of the cervical spine-injured athlete. *J Athl Train.* 2009;44(3):306-331.
6. Kleiner DM, Almquist JL, Bailes J, et al. *Prehospital Care of the Spine-Injured Athlete: A Document From the Inter-Association Task Force for Appropriate Care of the Spine-Injured Athlete.* Dallas, TX:

- Inter-Association Task Force for Appropriate Care of the Spine-Injured Athlete; 2001.
7. Decoster LC, Shirley C, Swartz EE. Football face-mask removal with a cordless screwdriver on helmets used for at least one season of play. *J Athl Train*. 2005;40(3):169–173.
 8. Gale SD, Decoster LC, Swartz EE. The combined tool approach for face mask removal during on-field conditions. *J Athl Train*. 2008;43(1):14–20.
 9. Copeland AJ, Decoster LC, Swartz EE, Gattie ER, Gale SD. Combined tool approach is 100% successful for emergency football face mask removal. *Clin J Sport Med*. 2007;17(6):452–457.
 10. Swartz EE, Belmore K, Decoster LC, Armstrong CW. Emergency face-mask removal effectiveness: a comparison of traditional and nontraditional football helmet face-mask attachment systems. *J Athl Train*. 2010;45(6):560–569.
 11. Toler JD, Petschauer MA, Mihalik JP, Oyama S, Halverson SD, Guskiewicz KM. Comparison of 3 airway access techniques during suspected spine injury management in American football. *Clin J Sport Med*. 2010;20(2):92–97.
 12. Gatti JM, Scibek JS, McKenzie JI. Success rate in removal of a new football helmet face mask attachment system after one season of use [abstract]. *J Athl Train*. 2009;44(suppl):S84–S85.
 13. Swartz EE, Norkus SA, Cappaert TA, Decoster LC. Football equipment design affects face mask removal efficiency. *Am J Sports Med*. 2005;33(8):1210–1219.
 14. Swartz EE, Decoster LC, Raskow J, Hernandez A. Face mask removal efficiency in a newly designed quick release face mask attachment system [abstract]. *J Athl Train*. 2008;43(suppl):S81–S82.
 15. Jenkins HL, Valovich TC, Arnold BL, Gansneder BM. Removal tools are faster and produce less force and torque on the helmet than cutting tools during face-mask retraction. *J Athl Train*. 2002;37(3):246–251.
 16. Ray RR, Luchies CW, Bazuin D, Farrell RN. Airway preparation techniques for the cervical spine-injured football player. *J Athl Train*. 1995;30(3):217–221.
 17. Swartz EE, Decoster LC, Norkus SA, Cappaert TA. The influence of various factors on high school football helmet face mask removal: a retrospective, cross-sectional analysis. *J Athl Train*. 2007;42(1):11–19.
 18. Ray RR, Luchies C, Frens MA, Hughes W, Sturmfels R. Cervical spine motion in football players during 3 airway-exposure techniques. *J Athl Train*. 2002;37(2):172–177.

Address correspondence to Tonia Gruppen, MS, ATC, DeVos Fieldhouse, Hope College, 222 Fairbanks Avenue, Holland, MI 49423.
Address e-mail to gruppen@hope.edu.