 2012 Aug;47(4):428434. doi: 10.4085/1062-6050-47.4.10Whereas many researchers have assessed the ability to remove loop straps in traditional face-mask attachment systems after at least 1 season of use, research in which the effectiveness of the Riddell Quick Release (QR) Face Guard Attachment System clip after 1 season has been assessed is limited.To examine the success rate of removing the QR clips after 1 season of use at the Football Championship Subdivision level. We hypothesized that 1 season of use would negatively affect the removal rate of the QR clip but repeated clip-removal trials would improve the removal rate.Retrospective, quasi-experimental design.Controlled laboratory study.Sixty-three football helmets from a National Collegiate Athletic Association Division I university located in western Pennsylvania used during the 2008 season were tested.Three certified athletic trainers (2 men, 1 woman; age = 31.3 3.06 years, time certified = 9.42 2.65 years) attempted to remove the QR clips from each helmet with the tool provided by the manufacturer. Helmets then were reassembled to allow each athletic trainer to attempt clip removal.The dependent variables were total left clips removed (TCR-L), total right clips removed (TCR-R), and total clips removed (TCR). Success rate of clip removal (SRCR) also was assessed.Percentages for TCR-L, TCR-R, and TCR were 100% (189 of 189), 96.30% (182 of 189), and 98.15% (371 of 378), respectively. A paired-samples t test revealed a difference between TCR-R and TCR-L (t_{188} = 2.689, P = .008, d = 0.037, 95% confidence interval [CI] = 0.064, 0.010). The percentage for SRCR was 96.30% (n = 182), whereas SRCR percentages for trials 1, 2, and 3 were 95.24% (n = 60), 98.41% (n = 62), and 95.24% (n = 60), respectively, and did not represent a difference ($F_{2,186}$ = 0.588, P = .56, 95% CI = 0.94, 0.99).Our results indicated favorable and consistent success rates for QR clip removal after 1 season of use. Whereas the QR clip is an advancement in face-mask technology, continued examination of this system is required to ensure the highest level of function, allowing for effective management of the helmeted athlete.Key Words: quick release attachment system, protective equipment, equipment removal, emergency managementAfter 1 season of collegiate football use, the Riddell Quick Release Face Guard Attachment System side clips demonstrated favorable results, with 98% of all clips being removed successfully within a clinically acceptable time frame.Both side clips could be removed in approximately 96% of cases, allowing for face-mask retraction.The removal rate did not increase over time.Regular equipment maintenance, refurbishment, and reconditioning must be emphasized at all levels of football.Athletic trainers must practice and familiarize themselves with the improvements and challenges that new equipment developments might present during potentially life-threatening situations.Frequently, discussions of injury management involving the helmeted athlete result in some mention of maintaining spinal alignment in suspected cases of spinal cord injury and ensuring appropriate airway access. The safety of the athlete and prevention of further injury remain the focus. To this end, many investigators have examined questions related to equipment removal and cervical spine motion,13 airway access techniques,4,5 and techniques and efficiency of face-mask removal.613 Evidence has suggested that airway access can be obtained in the football-helmeted athletes without the removal of the face mask, ultimately reducing motion of the cervical spine often associated with face-mask removal.4,5,14 However, the National Athletic Trainers' Association15 and the Inter-Association Task Force for the Appropriate Care of the Spine-Injured Athlete16 advocate full removal of the football face mask under all circumstances. Numerous tools have been examined, including the Trainer's Angel (Trainer's Angel, Riverside, CA), polyvinyl chloride cutter, anvil pruner, FM Extractor (Sports Medicine Concepts, Inc, Livonia, NY), and both manual and cordless screwdrivers. All have been described as viable methods for face-mask retraction and removal. However, the efficiency of face-mask removal and the extent to which cervical spinal motion is generated by using these tools have been questioned considerably.8,9,11,13,14 Gale et al12 and Copeland et al6 suggested a combined-tool approach, indicating that using a cordless screwdriver and the FM Extractor when screws fail is fast, easy, and reliable. More recently, Toler et al14 reported that access was quicker and helmet motion was less when using the Revolution IQ (Riddell Sports, Inc, Elyria, OH) helmets equipped with the Quick Release (QR) Face Guard Attachment System (Riddell Sports, Inc) than when using helmets that require removing clips with a cordless screwdriver.Technological advances in football helmet design and construction often have occurred in response to fatalities in football and head injuries.17 Given the inherent challenges of face-mask removal, clinicians must be aware of the advancements that have occurred with respect to face-mask attachment systems.7,10,18 One advancement in 2002 involved a spring-loaded mechanism nut-and-bolt system that secured the face-mask clip to the helmet.7 Removal of the clip required a one-quarter turn with a flat-head screwdriver to release the clip from the face mask and helmet. Jenkins et al7 noted less time required to remove the face mask and reduced forces and torques associated with face-mask removal using this system than the FM Extractor and Trainer's Angel. In 2005, Swartz et al10 examined the time, torque, and helmet movement associated with removal of the Revolution side-slotted loop strap. When comparing different removal-tool conditions and face-mask attachment systems, they noted more cervical spine flexion and extension when attempting to remove the Revolution clip with a screwdriver. In addition, perceived exertion and time required to remove the face mask were increased when attempting removal with the FM Extractor, which was attributed to the proximity of the clip on the lateral aspect of the helmet and the shoulder pads.10 Riddell Sports, Inc, since has released the QR clip, which uses a spring-loaded mechanism and requires a special tool to depress a pin-release mechanism. In a recent study involving new, unused helmets outfitted with the QR clip, Swartz et al18 documented fast and easy face-mask release, with limited helmet motion and 100% success rate for face-mask removal. Previous researchers have made considerable efforts to assess the ability to remove loop straps in traditional T-nut and screw face-mask attachment systems after at least 1 season of use11,19; unfortunately, no researchers specifically have addressed the success rate of QR clip removal after 1 season of use.The dearth of information about routine maintenance of the QR clip is similar to that about successful clip removal after 1 season of use. Generally, investigators have suggested routinely inspecting the integrity of football helmets and face masks and observing for excessive wear and material failure (ie, cracks). Similarly, the fit of a helmet should be monitored throughout a season. Unfortunately, unless a face-mask clip becomes detached or fails during routine helmet maintenance, dysfunctional face-mask clips can go unchecked and undetected. Traditionally, helmets undergo reconditioning at the conclusion of a season. Whereas some researchers have examined the face-mask removal rates of helmets set to undergo reconditioning,6,19 only Gale et al12 have examined face-mask removal during the season, noting excellent face-mask removal rates using a combined-tool approach. However, no investigators have addressed the function of the QR clip during or at the conclusion of a football season. The literature provides no evidence to support the effect of multiple QR clip removals on function or the effects of repeated removal and reinstallation of the QR clip to ensure successful removal during an emergency. Therefore, the purpose of our study was to examine the success rate in removing the QR Face Guard Attachment System clips after 1 season of use at the Football Championship Subdivision level in the western Pennsylvania climate. We hypothesized that 1 season of use would negatively affect the removal rate of the QR clip compared with previously reported new and unused QR clip-removal rates.18 We also hypothesized that repeated trials of clip removal ultimately would improve the rate at which QR clips could be removed.We used a retrospective, quasi-experimental research design and performed all data collection in a controlled laboratory environment. Revolution IQ football helmets retrofitted with the QR Face Guard Attachment System during reconditioning before the 2008 football season were used in this study. The QR replaced traditional Revolution IQ side loop straps for face-mask attachment. The QR clip consists of a spring-loaded locking-pin mechanism, which is used to secure the side loop strap to the helmet (Figure 1). To release the QR clip from the helmet, a specially designed QR Combo Installation Tool (part 27515; Riddell Sports, Inc) is used to depress the centrally located pin (Figure 2). Each helmet used a traditional Revolution IQ top loop-strap system to secure the top of the face mask to the helmet. With the side QR clips released and the traditional top loops intact, the face mask could be retracted. Retraction is not recommended during management of a helmeted athlete because of the potential for increased cervical spine motion with the face mask retracted.13,16 However, we sought only to examine removal rates associated with the QR clip alone and not to examine the entire face mask. Revolution IQ (Riddell Sports, Inc, Elyria, OH) helmet retrofitted with Quick Release Face Guard Attachment System (Riddell Sports, Inc) clip. A, Lateral, and B, superior views of the Quick Release Face Guard Attachment System (Riddell Sports, Inc, Elyria, OH) clip, and C, the Quick Release Combo Installation Tool (part 27515; Riddell Sports, Inc).Our sample consisted of 63 helmets, totaling 126 QR clips (left = 63, right = 63). The distribution of the helmets worn by position is provided in the Table. Over the course of the season, the helmets were worn for 72 practices, which occurred on a synthetic field surface in western Pennsylvania, and 10 games, which took place on both grass and synthetic field surfaces in Pennsylvania (7 games), New York (1 game), Connecticut (1 game), and Rhode Island (1 game). All helmets were tested 2 days after the final game of the 2008 regular season and were scheduled to be reconditioned before the start of the 2009 football season.Football Helmet Distribution by PositionThree certified athletic trainers (2 men, 1 woman; age = 31.3 3.06 years, time certified = 9.42 2.65 years, hand dominance = right) from the university performed all of the helmet testing and collected all data. Two of the athletic trainers (J.M.G., J.I.M.) were responsible for the medical coverage of football at the university, and 1 (J.S.S.) was employed in the university's undergraduate athletic training education program and was involved clinically off campus. Before initiating data collection, each athletic trainer went through the same familiarization process. The athletic trainers were provided with a copy of the literature from Riddell Sports, Inc, outlining the instructions for QR clip removal and refastening. Next, they practiced using the removal and installation tool on a new Revolution IQ helmet outfitted with new QR clips. Because 2 of the athletic trainers worked with the football program and were accustomed to the clip design, removal, and installation, the familiarization process primarily served as an opportunity for the third athletic trainer to gain familiarity with the equipment and technique required for successful clip removal and reattachment.Whereas authors of many studies of this nature have used a specially fabricated helmet-stabilization device,6,7,11,19 we decided that one of the athletic trainers would manually stabilize the helmet using techniques similar to actual stabilization techniques that would be performed during an emergency situation. Over the course of 3 trials, each athletic trainer stabilized the helmet once (Figure 3). Helmets were removed randomly from each athlete's locker for testing without regard for position or playing time during the season. All testing occurred in a controlled environment adjacent to the locker room that provided easy access to the locker room and was free from interruptions. Testing order for each athletic trainer was randomized by placing each individual's name on 3 separate pieces of paper, then drawing names from a container. The same randomization technique was used to determine which QR clip (right, left) would be removed first. Similarly, each athletic trainer randomly selected 1 of 8 installation tools before each trial. During each trial, the third athletic trainer monitored the testing time and recorded the number of attempts required within a trial to remove each QR clip. All helmets were tested during 1 day of data collection by each athletic trainer. To reduce the effect of fatigue on our results, each athletic trainer rested for a minimum of 3 minutes between trials. The randomized testing order resulted in multiple occurrences of greater than 3 minutes of rest for each clinician. Football helmet stabilization and Quick Release Face Guard Attachment System (Riddell Sports, Inc, Elyria, OH) clip removal. Manual stabilization of the helmet was performed to mimic helmet-stabilization techniques used during an emergency situation. For clip removal, one hand was used to manipulate the tool, and the other hand provided stabilization and pulled the clip from the helmet after release of the locking-pin mechanism.An attempt was defined as an instance in which the athletic trainer depressed the pin and subsequently tried to remove the clip. In addition, if the tester removed pressure from the pin or altered hand or tool placement, an attempt was recorded. Successful clip removal was defined as the ability to remove 1 QR clip within 15 seconds and to remove both QR clips within 30 seconds. The testing time started when the athletic trainer performing the clip removal was given the command to begin and stopped when the timer reached 30 seconds. Researchers using a spring-loaded nut-and-bolt system have suggested that 2 side-strap QR clips can be removed in 20.9 9.0 seconds,7 whereas removal of slotted side straps and top loop straps can be performed in 53.4 21.5 seconds.10 Therefore, we believed that allotting 15 seconds per clip was justified. A more recent study18 designed to investigate the same version of the QR clip we examined lent additional support to our design when the authors noted that all 4 loop straps associated with the Revolution IQ helmet, including QR clips, could be removed in 33.96 14.14 seconds. Each athletic trainer started on the randomly selected side of the helmet and was instructed to perform clip removal on 1 side and then to move to the opposite side to complete the clip-removal trial. After the first athletic trainer attempted removal of the QR clips, the helmet was reassembled and the next randomly selected athletic trainer attempted removal of the clips for the same helmet. This protocol was followed 3 times to allow each athletic trainer to remove both clips from the same helmet.The variables that we assessed included total left clips removed (TCR-L), total right clips removed (TCR-R), total clips removed (TCR), and success rate of clip removal (SRCR). The SRCR was defined as the ability to successfully remove both QR clips within the allotted time. Success rate percentages were calculated for each condition. We also quantified the total number of attempts made using the clip-removal tool within a given clip-removal trial to garner a sense of the difficulty associated with the removal of each clip. A paired-samples t test was used to compare differences in removal rates for TCR-R and TCR-L. Using a 1-way analysis of variance (ANOVA), we assessed differences in SRCR with respect to testing order. We used an independent t test to assess differences between successful and unsuccessful clip-removal attempts, and we used the Levene test to evaluate the assumption of equal variance between these groups. An level of .05 was set a priori. We used SPSS (version 17.0; IBM SPSS, Armonk, NY) to perform all analyses.A total of 63 helmets were tested, and all helmets tested had 2 QR clips. Given that each helmet underwent testing 3 times, the total clip sample size was 378 clips (189 left clips and 189 right clips). Percentages for TCR-L, TCR-R, and TCR were 100% (189 of 189), 96.30% (182 of 189), and 98.15% (371 of 378), respectively. The paired-samples t test revealed a difference between TCR-R and TCR-L (t_{188} = 2.689, P = .008, d = 0.037, 95% confidence interval [CI] = 0.064, 0.010). Clip-removal failures were distributed throughout the first two-thirds of all helmets tested, and all clinicians experienced clip failures during testing, suggesting that clip-removal failures were not the result of fatigue during testing. Of the 7 clips that failed, 4 were attributed to 4 different helmets worn by offensive linemen. The remaining 3 failures were isolated to the helmet worn by 1 wide receiver.The percentage for SRCR across all trials was 96.30% (182 of 189), whereas SRCR percentages for trials 1, 2, and 3 were 95.24% (60 of 63), 98.41% (62 of 63), and 95.24% (60 of 63), respectively. The 1-way ANOVA revealed no difference for SRCR with respect to trial ($F_{2,186}$ = 0.588, P = .56, 95% CI = 0.94, 0.99).The mean number of attempts required to remove the QR clips successfully was 1.06 0.24 and 1.09 0.33 for the left and right clips, respectively. When clip-removal failure occurred, the mean number of attempts increased to 2.67 1.18, which represented a 2.4-fold increase. The Levene test for equality of variances revealed different variances (F = 91.06, P = .001) for the means of successful and failed clip-removal attempts. An independent t test, assuming unequal variances, revealed differences between the mean number of attempts for successful and failed clip removal ($t_{14.19}$ = 5.17, P = .001, 95% CI = 2.23, 0.92).We examined the removal rate of a new face-mask attachment system, which is designed to allow for rapid and effortless face-mask clip removal. In promotional material, Riddell Sports, Inc, claimed that the Riddell QR clip removal was 100% successful without mentioning the extent of helmet use. We were concerned with the QR's continued effectiveness after being exposed to the climate and the rigors inherent to 1 season of collegiate football use. After the collegiate football season, we successfully removed the left QR clip in all clip-removal trials, resulting in a 100% TCR-L. However, our success rate for TCR-R was 96.30%. In total, when combining the success associated with removal of both right and left clips, 98.15% were removed successfully with the installation tool alone. Anecdotally, we found that removing the left clips was easier and speculated that the combination of hand dominance and body positioning relative to the helmet might have facilitated clip-removal efforts on the left side of the helmet.The clip-removal rates we observed are not unlike both face-mask clip and face-mask removal rates observed in the works of others. In 2005, Decoster et al11 examined football face-mask removal after 1 season of use for 3 New England high schools. They noted that the screws associated with the side straps in all helmets were removed successfully 90% of the time, which was less than the screw-removal rate of the top straps (98%). They also noted that the mean time required to accomplish screw removal was 26.9 5.83 seconds for all 4 loop straps.11 Similarly, in 2005 Swartz et al10 noted that in 344 of 384 face-mask removal trials, 89.6% of the trials were successful. However, in 19 of 25 cutting attempts that were unsuccessful because of time, the design of the Revolution side strap and the ability to use select cutting devices might have been limiting factors.10 Gale et al12 suggested a 98.6% face-mask removal success rate over the course of a collegiate football season, with timing of face-mask removal throughout the season having no effect on success rate or removal time. In a study involving 600 used football helmets, Copeland et al6 found that using the FM Extractor or a combined approach with a screwdriver and FM Extractor for face-mask removal resulted in 99.4% and 100% success rates, respectively. Lastly, Swartz et al18 identified a 100% successful face-mask removal rate when using new, unused Revolution IQ helmets with the newest version of the pin-driven QR clip. When the QR clip was altered, examiners had to use a cutting tool to attempt clip removal, resulting in a 72.9% success rate for clip removal.18 In each of these studies,6,1012,18 various clip-removal techniques were described. We believe that these exceptionally high rates associated with both new and used helmets are a testament not only to work on the part of manufacturers to design easily removable clips but also to the efforts of clinicians, investigators, and manufacturers to identify the most appropriate devices for removing face masks.We also hypothesized that the QR clip would perform least favorably in early removal trials and would perform better in successive trials. Our rationale for this hypothesis was that the early attempts would loosen the QR pin, facilitating clip removal in subsequent trials. Looking across all trials for each athletic trainer, they successfully removed both QR clips, allowing for face-mask retraction in 182 of 189 trials, which equated to a 96.30% SRCR. However, we found no differences when looking at the ability to successfully remove both clips across trials, causing us to reject our second hypothesis. One factor that prevented us from achieving a 100% success rate was that for 1 of the 63 helmets tested, each of the athletic trainers did not successfully remove both clips because of difficulty removing the same right clip. We believe that failure of this single clip was the result of excessive wear. In the 4 other separate instances in which the right clip did not disengage, no obvious damage or excessive wear was noted. These observations are interesting and unexpected given the distribution of clip failures in relation to the helmet positions tested. Anecdotally, one would expect excessive wear to be associated with the helmet of a lineman as opposed to a wide receiver; yet this was contrary to our findings and suggests that routine maintenance might be necessary regardless of playing position. In addition, clip failures in these instances were not consistent with respect to a particular trial or clinician. Whereas some might argue that the unsuccessful clip removal in later trials was the result of faulty reinstallation, we draw attention to the fact that these failed clip removals occurred 50% of the time during the first trial of clip removal and 50% of the time during the third removal trial. However, we did note 2 trends among the clinicians during testing. First, when clip failure occurred, the clinician could not remove the clip within the allotted time or with a time extension. Second, when a clinician required multiple attempts or could not remove a clip, the other clinicians also tended to have difficulty with the respective clip. Our analysis confirmed this second observation, demonstrating that when a clip was removed successfully during all 3 trials, the average number of attempts per clip was equal to 1.06 and 1.09 for left and right clips, respectively. When failure to remove a clip occurred, the average number of attempts to remove the clip tallied 2.67 attempts. When considering the complete failure of 1 clip and the separate instances of clip failure accompanied by subsequent clip-removal difficulty, it is likely that any instances of clip failure were the result of defective or dysfunctional clips rather than reinstallation or clinician error. Although some might question the second and third trials of clip removal as they relate to clip removal after 1 season of use, these data provide us with greater insight into the effectiveness and required maintenance of the QR clip. Our results suggest that priming or repeated removal and reinstallation of the QR clip does not improve either the function of or one's ability to remove the QR clip. However, based on our findings and noted trends, we recommend routine clip-removal checks and replacement of faulty clips throughout the season to facilitate a 100% removal rate and to optimize levels of function in advance of a possible emergency.Whereas our results appear to suggest exceptionally high success rates with respect to clip removal, we also must consider the clinical effect that our inability to remove both clips could have had in an emergency situation. Any limitation in clip removal could affect accessibility to the patient's airway. Although we removed 98.15% of all clips, we obtained an SRCR of only 96.30%. In light of the difficulty encountered with some of the right QR clips, our accessibility and potential for face-mask removal would have been limited in a clinical situation. Given the nature of the study, it was important that testing conditions remained the same for each athletic trainer; therefore, when the helmets were reassembled between trials, the same hardware was used even if the previous rater had difficulty disengaging the mechanism. However, in a clinical situation, any difficulty associated with clip and face-mask removal warrants the immediate replacement of the face-mask clip to limit the possibility of clip failure or failure to remove the face mask (or both). We do not know to what extent regular maintenance was practiced during the football season and what effect it might have had on our overall results.Because of our study design, we also did not know the extent to which helmet motion was generated during our attempts at QR clip removal, which again could have considerable clinical implications. As clinicians, we must be cognizant of the implications associated with difficult clip removal and the introduction of unwanted helmet and cervical spine motion during face-mask removal. Gastel et al1 examined the cervical spine motion associated with helmet and shoulder-pad removal using a cadaveric model and provided evidence to support the level of care and caution that must be exercised when working with a helmeted athlete, particularly when the player is wearing shoulder pads. A number of researchers4,710,13,14 have assessed motion and the direction of forces being applied to the helmet and cervical spine during face-mask removal. With respect to clip cutting, some of the cutting tools seem to be more effective than others for limiting helmet and spine motion.4,8,9,13 However, and more importantly, the evidence clearly indicates that removal of the clips via a screwdriver results in far less motion of and force being applied to the helmet than cutting face-mask clips.7,10 The results for the QR clip have been favorable as they relate to head and cervical motion generated during face-mask removal.14,18 Ultimately, the evidence-based best practice would include a combined-tool approach, relying on a cordless screwdriver, the QR installation tool, and a cutting device (most notably, the FM Extractor) because of the level of success associated with these tools as it relates to time required, cervical spine and head motion generated, and ease of use for the clinician.6,11,12,14Overall, our reason for conducting this study was to investigate the effectiveness of the spring-loaded, locking-pin mechanism of the QR clip. We are unsure if our success rate would have been higher if we had used the combined-tool approach that has been advocated in a number of similar studies6,11,12,18,19 to facilitate successful and timely face-mask removal. The time limits often associated with successful face-mask removal range from 30 seconds to 4 minutes and have been based on the amount of time it takes to use various face-mask removal tools under varying conditions4,79,11,12,14,18 and the time frame in which irrecoverable brain damage is likely if resuscitation does not occur and circulation is not restored.20,21 Considerable evidence also has been presented on speed, efficiency, and movement generated with various face-mask clip conditions and clip-removal devices.414,18 Some investigators4,5,14 have even studied alternatives to providing respiratory assistance with a face mask in place. Toler et al14 and Swartz et al18 identified similarities in head or helmet motion associated with face-mask removal when comparing QR-equipped face masks and face masks requiring use of a cordless screwdriver. They both noted the time required to remove face masks was less for helmets equipped with QR clips than for helmets equipped with other face-mask attachment systems.14,18 Toler et al14 also recently showed that the time required to provide airway assistance was less when using a pocket-mask insertion technique (approximately 20 seconds) than when removing the face mask using a cordless screwdriver (approximately 70 seconds) and when removing the face-mask QR clips (approximately 50 seconds). Furthermore, less head motion was observed with the pocket-mask insertion technique, and the difference between head and helmet motion tended to be less when using the pocket-mask insertion technique than the other face-mask removal techniques.14 Whereas the evidence supports use of the QR clip because of its ability to facilitate quick and efficient face-mask removal,14,18 Toler et al14 provided clinicians with an alternate method to ensuring quick and efficient airway accessibility when the QR pin mechanism failed. Regardless of the evidence, we support the recommendations of other investigators,1012,14,18 cautioning athletic trainers to practice, to be prepared with alternative cutting devices, and ultimately to be familiar with the equipment that their athletes might be wearing.We cannot draw any conclusions about whether the clip-removal success rates we observed were affected by the number of games, total number of practices, playing surfaces, or weather conditions that the equipment encountered throughout the course of the season because helmets were not tested before or throughout the season. Based on the findings of others who have studied successful face-mask removal after football helmet use after 1 season, environmental conditions seem to have little effect on these removal rates. Decoster et al11 could not draw conclusions concerning the effect of weather conditions and playing surfaces on face-mask removal after 1 season of high school use. They suggested that varying types of hardware used to fasten the clips and the unprotected location of the side clips from sweat and environmental conditions could have affected face-mask removal rates.11 Although Copeland et al6 engaged in a large-scale study that also involved used high school football helmets identified from 2 reconditioning facilities within the United States (1 in the Northeast and 1 in the Midwest), they could not draw any conclusions relative to environmental or use conditions. However, they noted the implications associated with varying loop-strap designs, the effect of variations in screw metallurgy, and the interaction between clip design and select cutting tools.6 When looking at helmets being used throughout a collegiate football season, Gale et al12 documented no differences in removal times throughout the season or between Riddell helmet models (VSR4 and Revolution) and no relationship between face-mask removal or removal time and dry-bulb temperature or relative humidity. Although Swartz et al19 recognized differences in analyzed weather characteristics and in face-mask removal rates by region of the United States, they also noted that regional failure rates are multifactorial and might be linked more closely to hardware metallurgy, corrosion, and equipment maintenance.The design of our study had some limitations. We did not acquire data on removal rates before the start of the season. Therefore, we could not determine what effect 1 season of use might have had on the function of QR clips and suggest an evaluation of this question in the future. As mentioned, our design did not allow us to collect data associated with other removal or cutting tools, so we could not assess what sort of effect they might have had on our overall success rates of clip removal. Whereas we attempted to simulate helmet and cervical spine stabilization during testing, the inclusion of some additional elements would have enhanced the quality of our simulated scenario. At minimum, placing a weight in the helmet to simulate the weight of the human head would have been helpful. A live model in full equipment would have been ideal. However, because of variations in the sizes of the helmets being tested, involving the actual wearers of the equipment likely would have been most appropriate to optimize the simulation, as in the work of Gale et al.12 Last, the incorporation of a live model along with a force plate and kinematic data-collection system would have enabled us to examine the forces and cervical spine motion associated with QR clip removal after 1 season of use.After 1 season of collegiate football use, the Riddell QR face-mask side clips demonstrated very favorable results, with 98% of clips being removed successfully within a clinically acceptable time frame. In addition, we noted that in approximately 96% of all cases, both side clips were removed, which allowed for face-mask retraction. We also found that this removal rate did not increase over time. When faced with potential airway or cervical spine compromise, our ability to remove face-mask clips quickly and efficiently and in a manner that minimizes helmet and cervical spine motion is paramount. Therefore, regular equipment maintenance, refurbishment, and reconditioning must continue to be emphasized at all levels of football.Equipment manufacturers will continue to make great strides in advancing the safety and technology of helmets. As advancements occur in the development of sports equipment, athletic trainers must continue to study the effectiveness and safety of these new technologies. We must continue to familiarize ourselves with the improvements and challenges that these new equipment developments will present during potentially life-threatening situations. Through our efforts, including the education of other allied health care professionals, we will be able to help ensure an optimal level of preparedness when addressing potentially catastrophic and life-threatening situations.We thank Tessa Chopra, ATC, CSCS, PES, and Andrew Pope, ATC, PES, EMT-B, for their assistance with the literature review and data processing.1.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):411417. doi: 10.1016/s0196-0644(98)70168-4. [DOI] [PubMed] [Google Scholar]2.Peris MD, Donaldson WF, III, Towers J, Blanc R, Muzzonigro TS. Helmet and shoulder pad removal in suspected cervical spine injury: human control model. Spine (Phila Pa 1976) 2002;27(9):995998. doi: 10.1097/00007632-200205010-00022. [DOI] [PubMed] [Google Scholar]3.Waninger KN. On-field management of potential cervical spine injury in helmeted football players: leave the helmet on! 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[PMC free article] [PubMed] [Google Scholar]20.Basu S, Liu X, Nozari A, Rubertsson S, Miclescu A, Wiklund L. Evidence for time-dependent maximum increase of free radical damage and eicosanoid formation in the brain as related to duration of cardiac arrest and cardio-pulmonary resuscitation. Free Radic Res. 2003;37(3):251256. doi: 10.1080/1071576021000043058. [DOI] [PubMed] [Google Scholar]21.Menzebach A, Bergt S, von Waldthausen P, Dinu C, Nldge-Schomburg G, Vollmar B. A comprehensive study of survival, tissue damage, and neurological dysfunction in a murine model of cardiopulmonary resuscitation after potassium-induced cardiac arrest. Shock. 2010;33(2):189196. doi: 10.1097/SHK.0b013e3181ad59a3. [DOI] [PubMed] [Google Scholar] Context: An effective approach to emergency removal of the face mask (FM) from a football helmet should include successful removal of the FM and limitation of both the time required and the movement created during the process. Current recommendations and practice are to use a cutting tool to remove the FM. Researchers recently have suggested an alternate approach that combines the use of a cordless screwdriver and a cutting tool. This combined tool approach has not been studied, and FM removal has not been studied in a practical setting. Objective: To investigate the effectiveness and speed of using a combined tool approach to remove the FMs from football helmets during on-field conditions throughout the course of a football season. Design: Randomized multigroup design. Setting: Practice field of 1 National Collegiate Athletic Association Division II football college. Patients or other participants: Eighty-four members of 1 football team. Intervention(s): We used a battery-operated screwdriver for FM removal and resorted to using a cutting tool as needed. Main outcome measure(s): We tracked FM removal success and failure and trial time and compared results based on helmet characteristics, weather variables, and the seasonal timing of the removal trial. Results: Of the 84 players, 76 were available for data-collection trials. Overall, 98.6% (75/76) of FM removal trials were successful and resulted in a mean removal time of 40.09 +/- 15.1 seconds. We found no differences in FM removal time throughout the course of the season. No differences in effectiveness or trial time were found among helmet characteristics, weather variables, or the timing of the trial. Conclusions: Combining the cordless screwdriver and cutting tool provided a fast and reliable means of on-field FM removal in this Division II setting. Despite the excellent overall result, 1 FM was not removed in a timely manner. Therefore, we recommend that athletic trainers practice helmet removal to be prepared should FM removal fail. Keywords: airway access; cervical spine; emergency management; football injuries; protective equipment. 2008 Jan-Feb;43(1):1420. doi: 10.4085/1062-6050-43.1.14An effective approach to emergency removal of the face mask (FM) from a football helmet should include successful removal of the FM and limitation of both the time required and the movement created during the process. Current recommendations and practice are to use a cutting tool to remove the FM. Researchers recently have suggested an alternate approach that combines the use of a cordless screwdriver and a cutting tool. This combined tool approach has not been studied, and FM removal has not been studied in a practical setting.To investigate the effectiveness and speed of using a combined tool approach to remove the FMs from football helmets during on-field conditions throughout the course of a football season.Randomized multigroup design.Practice field of 1 National Collegiate Athletic Association Division II football college.Eighty-four members of 1 football team.We used a battery-operated screwdriver for FM removal and resorted to using a cutting tool as needed.We tracked FM removal success and failure and trial time and compared results based on helmet characteristics, weather variables, and the seasonal timing of the removal trial.Of the 84 players, 76 were available for data-collection trials. Overall, 98.6% (75/76) of FM removal trials were successful and resulted in a mean removal time of 40.09 15.1 seconds. We found no differences in FM removal time throughout the course of the season. No differences in effectiveness or trial time were found among helmet characteristics, weather variables, or the timing of the trial.Combining the cordless screwdriver and cutting tool provided a fast and reliable means of on-field FM removal in this Division II setting. Despite the excellent overall result, 1 FM was not removed in a timely manner. Therefore, we recommend that athletic trainers practice helmet removal to be prepared should FM removal fail.Keywords: football injuries, protective equipment, emergency management, cervical spine, airway accessThe combination of the cordless screwdriver and cutting tool quickly and reliably enabled on-field face mask removal.A total of 98.6% of face masks were removed successfully with the combined tool approach.Athletic trainers should use the cordless screwdriver as the primary tool for face mask removal and should carry an appropriate backup cutting tool for use if the screwdriver fails.The face mask (FM) of a football helmet is a barrier to airway treatment in the emergency management of an injured football athlete. However, researchers13 have reported that spinal alignment can be disrupted if the football helmet is removed without the concurrent removal of the shoulder pads. Therefore, the Inter-Association Task Force for the Appropriate Care of the Spine-Injured Athlete4 (IATF) recommended that, to gain access to the injured athlete's airway, the rescuer should remove the FM from the helmet before transporting the athlete to the hospital. The IATF further recommended that the best FM removal tools should limit the time required for, and movement created during, the FM removal process. Because quick management is essential in respiratory emergencies and limitation of head and neck movement is imperative when addressing a potential injury to the spine, these 2 elements of FM removal are critical performance factors. Recently, researchers5,6 investigated several FM removal techniques, including the use of various cutting tools. Their results indicated that cutting tools did not always enable successful FM removal within a clinically reasonable amount of time (4 minutes or less)5,6 and that cutting tools could fail.6 Furthermore, compared with data reported for a manual7 and a cordless screwdriver (CSD),6,8 data from research on cutting tools have demonstrated longer removal times,5,6,9,10 increased difficulty for the rescuer removing the FM,6 more torque placed on the helmet,10 and significantly more helmet movement created during the task.6,9,11 Based on its superior performance in those studies, the CSD appears to be a better FM removal tool than the manual screwdriver and cutting tools that have been tested to date.However, before 2004, research on FM removal was limited to laboratory-based settings where new football equipment was used, and it left the reliability of employing the CSD on used equipment in question. Since then, researchers8,12 have investigated the failure rate for CSD FM removal in used football equipment. Those studies revealed significantly different screwdriver effectiveness among football teams, with the best results for successful FM removal as high as 90% to 100% and the worst results as low as 47%.12 Because excellent results are possible with the CSD and because use of the CSD can limit time and limit head and neck movement, Swartz et al12 and Decoster et al8 recommended a combined tool approach for emergency FM removal. In this approach, the CSD is the athletic trainer's primary tool for FM removal, and an appropriate backup cutting tool is immediately available for use in case of CSD failure. No one has investigated or validated this combined tool approach. In addition, no one has investigated FM removal during on-field situations with athletes.Therefore, the primary purpose of our study was to investigate the effectiveness (FM removal success or failure) and speed (time to complete the task) of a combined tool approach to removing the FMs from football helmets during on-field conditions throughout the course of a football season. Information relative to helmet brand, helmet model, hardware components (screw and loop-strap types), and weather conditions (temperature and humidity) was collected to enable further exploration, when appropriate, of the relationship with FM removal success and time. We developed 3 research hypotheses to guide the statistical approach: (1) Frequency of FM removal failures and the mean times to complete FM removal would increase as the season progressed. (2) Differences in FM removal failure and time to complete FM removal would exist between selected helmet characteristics. (3) No relationship would exist between the success of FM removal or time to complete FM removal and the dry-bulb temperature or percentage of relative humidity during the removal attempt.The subject pool included 84 National Collegiate Athletic Association Division II football players from 1 team at a local New England college; however, only 76 players (90.5%; age = 19 1.2 years, height = 182.7 6.3 cm, mass = 96.7 14.5 kg) were available for data collection. Before the first practice, participants signed an informed consent form. We set no other specific inclusion or exclusion criteria for participation in the study. The study was approved by the college's institutional review board.An SP100FR sling psychrometer (Mannix Testing and Measurement, Chicago, IL) was used to measure wet-bulb and dry-bulb temperature and relative humidity on each day of data collection. One rechargeable, battery-operated CSD (3.6-V pivot driver; Black & Decker, Towson, MD) was used for all FM removal trials (Figure 1A). One screwdriver battery was used throughout the study, and it was stored in a charger between data-collection sessions, resulting in a minimum of a 6-day charge before each session. We used the Phillips head bit that was packaged with the CSD. An FMxtractor (FMX; Sports Medicine Concepts, Inc, Geneseo, NY) that was new before the start of data collection was the cutting tool used in all trials where the CSD failed to remove all loop-strap screws (Figure 1B). A digital stopwatch was used to time all trials.The football team's season began August 11, 2005, and ended November 5, 2005, resulting in a total of 12 separate weeks for data collection. Before the start of the season, we used a computer-generated list (version 3.0; Research Randomizer, Middletown, CT) to randomly assign all participants to a testing date during 1 of the 12 weeks of the season. Beginning with the first practice and ending the last week of the season, 2 investigators traveled once each week to the football practice field to collect environmental data and attempt FM removal on players assigned to that week. Recorded environmental data included wet-bulb and dry-bulb temperature and percentage of relative humidity. To obtain the temperatures, the primary investigator used the sling psychrometer according to the manufacturer's instructions. Percentage of relative humidity was determined according to the scale provided by the manufacturer.Following environmental measurements, the first subject assigned to that day of data collection was identified and invited into the data-collection area. The investigators recorded individual helmet demographics (helmet brand, helmet brand, screw color, and loop-strap type) and subject demographics (age, height, mass, year in school, and football position). Participants were instructed to lie motionless and not to resist or assist motion at the head or neck during the data-collection procedure. Each player then assumed a supine position on the ground with his arms by his sides or clasped across the abdomen and with his legs extended in readiness for the beginning of the trial.The primary investigator (S.D.G.) performed all removal trials from a position behind the subject's head while maintaining stabilization with her knees (Figure 2A). The CSD and FMX were placed on the ground to the right of the investigator. Each trial was timed with a digital stopwatch by a second investigator. Timing started when the primary investigator picked up the CSD and stopped when the FM was removed completely from the helmet. The primary investigator used the same removal order for each helmet: she removed the screw securing the FM loop strap (1) near the right ear, (2) near the left ear, (3) at the right forehead, and (4) at the left forehead. After those 4 CSD attempts were completed, if 1 or more of the 4 screws had not been removed successfully, the FMX was used to cut away the loop strap or straps associated with the screw or screws that could not be removed (Figure 2B).Following each trial, data for successful or failed removal and for completion time were recorded. The next subject was invited to the data-collection area, and the procedure was repeated until data on all participants and trials for that day were collected. Upon return to the office, we entered and stored the trial data on a computer-based spreadsheet (Excel 2003; Microsoft Corp, Redmond, WA).A trial was classified as a success if the FM was removed completely with the CSD or through the combined use of the CSD and the backup FMX within 3 minutes. If the FM could not be removed, we classified the trial as an overall failure. The use of the 3-minute time limit represents a slight departure from previous research6 in which a 4-minute maximal trial time was used. We decided to reduce the allowed trial time after considering the time required to respond to an injured athlete on the field, perform an assessment, and perhaps roll the athlete into a supine position before actually starting the process of FM removal. Because 4 minutes represents a marker when permanent brain damage may occur in an anoxic individual, we believed that the time available for FM removal actually would be less than 4 minutes.In addition, when we encountered individual screw removal failures, we classified the reasons for those failures. Specific reasons for failure at individual screw sites included the following categories: (1) screw stripped (damage was pre-existing or was caused when the CSD did not turn the screw and stripped the screw head8 during the trial), (2) T-nut spinning (the CSD caused the screw head to turn but did not loosen the screw from the underlying T-nut on the inside of the helmet),8 (3) screw stuck (the CSD failed to turn the screw or T-nut), and (4) other (foreign substances were embedded in the screw head).At the completion of the study, data were transferred to SPSS (version 13.0; SPSS Inc, Chicago, IL) for analysis. The independent variables included helmet (helmet brand, helmet model, screw color, loop-strap type) and environmental (dry-bulb temperature and percentage of relative humidity) characteristics. Helmet-characteristic data were transformed into nominal values for inclusion in statistical analysis. Two dependent variables were included in the statistical analysis: (1) success or failure of FM removal and (2) time to completion of FM removal. The overall success or failure of FM removal and the failure of the CSD for each of the 4 categories were transformed into nominal values for inclusion in statistical analysis. We created frequencies for overall success and failure of FM removal and the failure of the CSD for each of the 4 characteristics. Means (SDs) were calculated for the removal time for each week of data collection and for the overall season. We used univariate analysis of variance (ANOVA) to test for differences in time for removal among each of the weeks of the season, and we conducted post hoc Scheff testing as necessary. Independent-samples t tests were used to detect differences in removal time between selected helmet characteristics. Pearson product moment correlations were used to examine relationships between removal time and the environmental characteristics. The was set a priori at .05 for all tests. The confidence interval (CI) was 95%.The 76 helmets worn by the participants who completed the study included 50 Riddell VSR4 (Elyria, OH), 25 Riddell Revolution, and 1 Schutt Air (Litchfield, IL). Based on a report from the football coach, all helmets had been reconditioned before the start of the season, and all screws (n = 304) were stainless steel. A variety of equipment-appropriate loop straps were encountered.The participants included 33 freshman, 15 sophomore, 17 junior, and 11 senior players who participated in the following positions: center (2), cornerback (1), defensive back (9), defensive end (6), defensive line (2), defensive tackle (6), kicker (1), linebacker (9), offensive line (13), quarterback (3), running back (6), safety (4), tight end (4), and wide receiver (10).With the combined tool approach, the FM was removed successfully from 75 of 76 (98.6%) helmets. The FMs were removed successfully with the CSD from 70 of 76 (92.1%) helmets. In the 6 cases in which the FM was not removed with the CSD, only 1 screw failed per helmet. This created a screw failure rate of 2.0% (6 of 304 total screws). Of those 6 screws that could not be removed using the CSD, 3 failed because of a foreign substance embedded in the screw head; 2 because of T-nut spinning; and 1 because of a stripped screw head. Of the 6 CSD failures, 5 of the 6 FMs were removed successfully with the backup FMX. One Riddell Revolution side loop strap could not be removed within the 3-minute time limit and represented the 1 overall trial failure. Other planned analyses to examine failure rates throughout the course of the season, and relationships those failure rates may have held with helmet and weather variables were not deemed appropriate because of insufficient failure episodes (n = 1).Mean removal time for the 75 FMs was 40.09 15.12 seconds (range = 24.8132.0 seconds, 95% CI = 36.70, 43.49). The mean FM removal times for each week are provided in the Table. The ANOVA results indicated no significant differences in mean FM removal time throughout the course of the season ($F_{11,74}$ = 0.991, P = .465, effect size = 0.147, observed power = .492). The independent-samples t test indicated no significant difference in FM removal time between helmet models (VSR4 = 38.6 16.8 seconds, Revolution = 43.6 10.8 seconds; t_{72} = 1.016, P = .131). No other helmet demographic was deemed appropriate for further statistical comparison of removal time or failure. No significant correlations were found between time required for FM removal and relative humidity (R = 0.141, P = .226) or dry-bulb temperature (R = 0.109, P = .352).Time for Face Mask Removal(s)The results of our study demonstrated that the combination of CSD and FMX provided a fast (mean = 40.09 seconds) and reliable (success = 98.6%) means of on-field FM removal in a Division II collegiate football team with no differences based on the timing of the removal attempt. Three research hypotheses were tested in this project: (1) Frequency of FM removal failures and the mean times to complete FM removal would increase as the season progressed. (2) Differences in failure to remove the FM and time to complete FM removal would exist among selected helmet characteristics. (3) No relationship would exist between the success of FM removal or time to complete FM removal and the dry-bulb temperature or percentage of relative humidity. Based on the analyses allowed by the data, the time elements of the 2 hypotheses were rejected, and the time element of the third hypothesis was accepted.The primary objective of our study was to determine the success rate and time to complete FM removal using a combined tool approach during the course of a football season. During the development of this study, we suspected that time and success of FM removal might change over the course of the season as helmets were exposed to the environment and daily wear and tear. Our results did not support this supposition, and this hypothesis was rejected. However, the relatively small sample size combined with the very small failure rate prevented us from drawing strong conclusions about the effect of season progression on FM removal success. A larger sample with more failures might reveal different results. The lack of change in removal time over the season is a statistically stronger result. Because of the lack of differences, all success and time findings are considered as a whole for purposes of comparison to past literature in this discussion.Results regarding the combined tool approach cannot be compared directly with previous research because investigations into this technique have not been reported. However, the results for the success rate of FM removal for the CSD in our investigation can be compared with results reported in 2 previous studies. Our removal success rate (92.1%) for the CSD is similar but superior to the overall results obtained by Decoster et al8 (82.4%) and Swartz et al12 (84%), who reported data collected from used high school helmets. The origin and makeup of the samples in those studies were quite different from the samples in our study; in both of the previous studies, multiple teams were included in the analyses, and comparison of the individual team results indicated significant differences among teams. Compared with our single college team, some of the high school teams previously tested had inferior removal success rates (as low as 47%), some had similar rates, and some had superior rates (up to 100%).12 In those earlier studies, a larger, more heterogeneous sample of helmet brands and models and a greater variety of metal hardware components were encountered. Authors8,12 from both studies suggested that the differences in metal composition of the screws and T-nuts encountered in their samples were likely important factors in the disparity found in removal success rates. In our study, the metal hardware was the same in all helmets.Regardless of tool, technique, or approach, the time required to remove the FM is a critical element of our study that can be compared with previous research. Our mean combined tool removal time (40.09 15.12 seconds, 95% CI = 36.70, 43.49) was at the faster end of CSD removal times reported by Swartz et al,6 who noted that means for various combinations of helmet and hardware ranged from 42.1 seconds to 68.8 seconds. The mean CSD removal time reported by Decoster et al8 (26.9 seconds) was faster than our time. However, the authors8 theorized that conditions better representing real-life situations might increase the time required to remove the FMs. Therefore, times in our study may better represent actual FM removal times because we collected the data on athletes during the season. Our results for the time to remove the FM in the combined tool trials are also faster than previously reported times in cutting-tool trials. According to Swartz et al,6 the mean time required to remove the FM using the original FM Extractor (Sports Medicine Concepts, Inc) ranged from 63.08 seconds to 203.33 seconds. In a 2003 study, Swartz et al5 found the following mean (SD) times for FM removal using various cutting tools: anvil pruner = 96.2 41.6 seconds, polyvinyl chloride pipe cutter = 155.9 63.8 seconds, and Trainer's Angel (Trainer's Angel, Riverside, CA) = 102.2 39.8 seconds. Clearly, FM removal times using the CSD or the combined tool approach are considerably faster.Although the overall success rate of this combined tool approach was higher than any other reported in the literature, it was still not 100% successful. Swartz et al12 showed that 100% removal success was possible in subpopulations, but we found that failure was still possible. Therefore, we agree with previous recommendations8,12 that athletic trainers should use a CSD as their primary tool for FM removal and use a backup cutting tool if the CSD fails to remove the FM. However, we further recommend that athletic trainers should practice helmet removal to prepare themselves in case that becomes necessary.Our second hypothesis also was rejected because no difference existed in the success rate or time needed to remove the FM between 2 common models of football helmets. We had based this hypothesis on the results of previous studies6,12 of heterogeneous samples that showed significant differences in FM removal success and time based on helmet brand, helmet model, loop-strap type, and metal hardware. The homogeneity of our sample did not enable us to make comparisons other than between helmet models. Consequently, although we rejected the second hypothesis, we drew this conclusion only for a comparison between 2 models of Riddell helmets; we could not make any conclusions regarding the effect of different helmet brands, loop-strap types, or screw types.Although we hypothesized a difference in the time required to unscrew the FM from different helmet models, our failure to find one is not unique. In a previous study, Swartz et al6 found no significant differences in the time required to unscrew the FM from different helmet models. In another study, the researchers12 reported a moderate correlation between helmet brands and the success of CSD FM removal. Swartz et al6 also reported differences in removal time and success with cutting tools among helmet brands. Importantly, a review of pertinent literature6,8,12 shows that, regardless of helmet characteristics, even the longest mean times associated with CSD FM removal appear to be clinically acceptable. This provides support for the use of the CSD as a primary FM removal tool.Differences in ambient weather conditions could have an effect on the ability to remove screws from the FM. For example, exposure to humid or rainy conditions might facilitate screw rusting or preclude proper function of the CSD. In our study, success rate or removal time appeared to have no relationship with the weather variables of dry-bulb temperature and percentage of relative humidity, leading us to accept our final hypothesis. We found no relationship between removal time and the environmental conditions studied. The only other research investigating weather considerations as they affect FM removal was retrospective,12 and the authors looked at the cumulative effects of weather conditions over the course of a football season. The authors12 theorized that the effects of differences in weather characteristics across 5 regions of the country could have a strong effect on FM removal. However, as in our study, they did not find a strong relationship between weather characteristics and FM removal.In addition to the effectiveness and time required to remove the FM, minimization of head and neck movement during the task is also an important consideration. Researchers have investigated the amount of movement or torque created during the process of both FM removal and retraction. Using various methods, Ray et al,7 Knox and Kleiner,9 Jenkins et al,10 and Swartz et al6 found that the CSD approach created less movement or torque than cutting techniques created. We did not analyze movement in the current study, but extrapolation from that previous research leads us to conclude that the combined tool approach created less movement than a pure cutting approach because the combined tool approach only required the use of a cutting tool for 6 of 304 loop straps.Because we tested the combined tool technique of FM removal in a practical, on-field setting, we did not have the luxury of choosing a research design with stronger controls for threats against internal validity. For example, to better control for potential confounding factors, such as differences encountered in helmet brands, helmet models, and hardware types, we would have had to assign participants prospectively into specific equipment groups. However, this presents a challenge in the football setting, where equipment worn by participants is chosen based on multiple factors, inhibiting external control. Furthermore, often throughout the season, the equipment that a participant is wearing is changed for a variety of reasons. Therefore, we tested participants on the date to which they were randomly assigned in the equipment in which they presented. This represented the actual position of an athletic trainer during a real-life situation. Although our chosen research design may have been susceptible to threats to internal validity, it had greater external validity than previous studies5,6,12 performed in the laboratory setting.Another clear limitation of this study was the small sample size and the resulting lack of generalizability to settings other than that of a Division II college football team using similar helmet brands and hardware and playing in the Northeast. The final limitation was related to the FM removal trials being performed by 1 investigator. Certainly an entry-level certified athletic trainer is qualified to perform this task, but, as previous research6 suggests, the cutting task is more difficult for some athletic trainers than for others. The sole investigator was a recent graduate who had limited practice with the combined-tool approach (CSD and cutting tool). The use of multiple investigators performing the data-collection process on a more heterogeneous sample would further increase generalizability.Our results demonstrated that the combination of CSD and FMX represents a fast and reliable means of on-field FM removal in this Division II setting. Based on the results of this and other studies, we recommend that athletic trainers use a CSD as their primary tool for FM removal and carry an appropriate backup cutting tool for use if the CSD fails. Finally, because even the combined tool approach may fail to remove the FM in a timely manner, we further recommend that athletic trainers practice the skill of helmet removal to prepare themselves in case they need to use it.Future researchers should repeat the methods of our study with a larger and more heterogeneous sample. Further research efforts might be expended to attempt to improve current procedures and equipment or to identify a single emergency procedure that would enable the athletic trainer to successfully gain access to the athlete's airway quickly and with limited head and neck movement.We thank Neil Duval, ATC; Aaron Copeland, ATC; Eric Gattie, ATC; Maureen Saliba, ATC; and Michael Sirois, ATC, for their assistance with data collection on this project.1.Palumbo M.A, Hulstyn M.J, Fadale P.D, O'Brien T, Shall L. The effect of protective football equipment on alignment of the injured cervical spine: radiographic analysis in a cadaveric model. 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Football face mask removal tools. Emergency football helmet removal. Emergency football face mask removal. Facemask removal tools.