NOCSAE®

THE NATIONAL OPERATING COMMITTEE
ON STANDARDS FOR ATHLETIC EQUIPMENT

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MEMORANDUM

TO: NFL Team Physicians

FROM: Glen Meredith, Ph.D., Executive Director

SUBJECT: Status Report

DATE: January 27, 1993

Please find enclosed a copy of the current NOCSAE research report. This report is provided as part of a grant from the NFL Charities to NOCSAE.

GM:jdm

c: Paul Tagliabue
John Miller, M.D.

NOCSAE Research Status Report

Voigt R. Hodgson, Ph.D.
January 26, 1993

Head - Neck Injury Reduction

1. Catastrophic Injury Epidemiology: Again in the 1992 season, serious head and neck injuries continued the low trend observed in the post NOCSAE period, particularly since the introduction of the recertification of used helmet revision in the helmet standard on 1977, almost concurrent with the 1976 high school rules change prohibiting butt blocking and face tackling. Unofficially, there were:

   - 1 death due to a subdural hematoma head injury in high school
   - 1 death due to thigh injury complications
   - 3 serious head injuries, outcome yet uncertain
   - 3 or 4 paralyzing neck injuries, of which 2 high school, 1 pro, 1 uncertain

   If the trend of the late 1950s-1968 had continued, there ~~would have been~~ 50-60 serious head injuries; and, if the trend of the 1971-1976 period had continued, there would have been over 20 paralyzing neck injuries in 1992.

2. Helmet - Face mask - Shoulder Pad Relationship to Serious Neck Injury: The game of football could not be played in the manner as we know it today, without the protection afforded by any of these three pieces of equipment. However, in order to have the freedom of motion to play the game of football, the neck can still be vulnerable to injury from forces transmitted through the helmet, despite using the best equipment available. These pieces are designed independently, but it is very important in our effort to further minimize the risk of paralyzing neck injuries, that we examine ways in which they can be made to work together to reduce injurious cervical spine loads.

   In the course of 23 years experience examining films and many x-rays of cervical fracture-dislocation injuries to football players, common features stand out. The films usually showed a hit in the front upper part of the helmet. The x-rays usually exhibited evidence of some compression-flexion load characteristics, with occasional unilateral damage indicative of lateral bending or torsion.

   Of recent concern to the professional football community, have been the paralyzing neck injuries to Utley of the Detroit Lions in the 1991 season and to Byrd of the New York Jets in the 1992 season. The initial impressions of some who have fleetingly observed these accidents on the screen, are that they were compression-flexion injuries from impacts to the top of the helmet, although very different scenarios. We are hoping to have the opportunity to examine these two accidents in more detail on our film analyzer.

   It is the author's opinion, in consultation with one of this country's leading neck injury experts, that one way of reducing the risk of this type of injury would be to have all player positions which could tolerate a full cage, to wear one, together with a very firm foam flexion limiting bumper laced into the front of the shoulder pads. The cage length and bumper, both of which are commercially available, would be adjusted to each player's anatomical structure by the player himself, according to tolerable motion restrictions imposed by his position. A simple free body analysis of an impact to the front top of the helmet, assumed to be acting in the mid sagittal plane, shows that when the impact forces the spine to flex and compress, the stress in the spine will be partly relieved if the face mask contacts the chest.

In this case, the spine axial compression caused by the superior-inferior component of force on the helmet will be partially relieved by a chest force component acting inferior-superiorly on the lower edge of the face mask. This same force acting on the mask will also provide an extension moment to oppose the flexion moment caused by the helmet force. In the event the impact would be unsymmetrical and tend to cause torsion, the friction of the face mask against a chest pad would oppose this loading also.

Further study by means of instrumented Hybrid III dummy and cadavers, to determine the limits of allowable head-spine travel before injury to the cord occurs, is essential to a full understanding of this problem, and the practicality of using face mask interference as a protective strategy.

3. Temporal Mandibular Joint (TMJ) Protection: Williams (1) has pointed out that temporomandibular disorder (TMD), which can affect mandibular opening, swallowing, chewing, hearing, headaches, concussion tolerance, balance and physical strength, as well as neck, shoulder, arm and finger pain and numbness, is one of the health hazards uniquely associated with contact sports such as football due to helmet blows. Any blow to either ~~helmet~~ or ~~face mask~~ is transmitted ~~to the TMJ through the chin~~ strap.

NOCSAE research in this area involves having Dr. Williams present his experience with the disorder including radiographic diagnosis, treatment and most importantly, prevention. He has found fractures of the bones in the vicinity of the jaw joint in 95% of football players examined. We will be examining the TMJ protector in the lab, when one of our medium sized head models is modified with TMJ force transducers. In the meantime, a field study was conducted in the 1992 season at the high school level to determine the guards' practicality and effectiveness in football. Results were very favorable. The guards lasted all season with very good player acceptance and no headaches, which had been a common complaint previously. No concussions were experienced in their nine game season. Two JV players which had experienced concussions in the early part of the season were fitted with TMJ protectors and had no further problems.

When the new head model is soon completed, it will be used to not only evaluate TMJ protectors, but all types of mouthguards, methods of helmet retention, and in the face mask standard test. At present the mask is not allowed to touch the face, usually the chin, for 36 inch drops of a medium sized head model wearing a helmet and mask, with the mask contacting a rigid anvil. This criterion has in the past, required modifications to prevent some masks from touching the face in this test, despite being popular even at the pro level. Under a ~~proposed~~ revision to the face mask standard, the no touch requirement would be replaced by a more justifiable and quantitative TMJ force criterion, significantly below known mandible fracture levels.

Padding Research

1. Thigh Pads: Thigh injuries can run the gammit of annoying to very serious. In the late part of the 1992 season, a young high school player received a thigh bruise, which eventually led to amputation followed by death due to a bacterial disease. There are a wide variety of pads in the field, most of which are apparently doing a credible job, however we have observed a significant difference in impact performance among new and used pads. Some have been sent to us with large air pockets in the foam under the shell. There is a need to screen the quality of new and used pads.

We have developed a procedure for testing generic pads utilizing the helmet drop test system which is available nationwide in 50 manufacturing and reconditioning plants. The tests for each type of pad, i.e. thigh, hip, knee, elbow, specialty, etc., differs only in the appropriate form on which the pad is fitted for impact test.

2. Shoulder Pads: Since its development, and especially since the 1976 rules changes prohibiting butt blocking and face tackling, the shoulder pad has been the primary point of impact in high school football, where a player in uniform can take or impact the maximum hit compared to other parts of the body. The purpose of a set of shoulder pads is to: 1) allow impacts between competitors in contact sports to occur with no or minimal risk of injury to parts of the body covered by the pads, due to direct impact to the pads; 2) provide this protection and allow the players freedom of motion to perform their varied function with minimum weight and bulk restrictions.

A comprehensive impact test for shoulder pads should: 1) assess impact attenuation over all essential areas of coverage; 2) determine effect of temperature and moisture on the material physical and performance characteristics; 3) determine the effect of a large number of repeated impacts on its structural integrity and impact attenuation efficiency; 4) determine its load transfer capabilities over critical areas; 5) design the tests in such a way as to encourage lightness, minimum bulk and weight and freedom of motion.

A standard series of impact tests to be conducted on a test setup as illustrated in the accompanying figure, is being prepared for review by the NOCSAE Technical Resource Committee.

Reference

1. Williams, E.D., Athlete's Jaw Disorder as it Relates to the Vital Cranial Triad, 1991, 1432 East Washington Lane, Philadelphia, PA 19138

Table F1
Tooth & TMJ Force Measures For Drops Onto Lower Front of
Plastic Full Cage Faceguard
Medium Head With Custom Boil & Bite Mouthguard
5/17/93 Data

Drop Ht.	Force Transducer Location								
Ht-in	1	2	3	4	5	6	7	SI	G
36	145	97	17	20	17	95	137	132	39
36	90	64	10	10	6	59	80	108	43
36	160	101	16	15	15	99	145	138	43
Average	132	87	14	15	13	84	121	126	42
Std. Dev.	37	20	4	5	6	22	35	16	2
peak resultant TMJ force either side = 189 lb, based on average									
48	175	112	22	25	25	112	152	238	61
48	160	110	25	25	21	112	136	231	61
48	160	107	27	25	22	109	136	239	62
Average	165	110	25	25	23	111	141	236	61
Std. Dev.	9	3	3	0	2	2	9	4	1
peak resultant TMJ force either side = 198 lb, based on average									
60	365	205	20	20	14	181	283	415	81
60	375	200	59	25	51	188	334	445	103
60	390	203	50	25	48	175	282	443	93
Average	377	203	23	23	38	181	300	434	92
Std. Dev.	13	3	20	3	21	7	30	17	11
peak resultant TMJ force either side = 428 lb, ave; guard hit chin									

Table F3
Tooth & TMJ Force Measures For Drops Onto Lower Front of
Plastic Full Cage Faceguard
Medium Head With Standard Boil & Bite Mouthguard
5/17/93 Data

Drop Ht.	Force Transducer Location								
Ht-in	1	2	3	4	5	6	7	SI	G
36	58	35	**	24	**	34	60	79	39
36	89	50	**	35	**	32	60	93	43
36	82	44	**	18	**	47	79	94	42
Average	76	43	**	26	**	38	66	89	41
Std. Dev.	16	8	**	7	**	8	11	8	2

peak resultant TMJ force either side = 87 lb, based on average

48	212	119	7	32	2	121	196	186	50
48	274	147	7	20	2	134	224	215	61
48	254	132	7	19	2	130	213	205	55
Average	247	133	7	24	2	128	211	202	55
Std. Dev.	32	14	0	7	0	7	14	15	6

peak resultant TMJ force either side = 281 lb, based on average

60	380	198	11	30	3	186	304	376	87
60	390	208	10	33	12	226	398	548	104
60	400	221	6	25	9	231	392	530	104
60	360	166	13	54	19	170	326	364	89
Average	383	198	10	36	11	203	355	455	96
Std. Dev.	17	23	3	13	7	30	47	98	9

peak resultant TMJ force either side = 431 lb, ave; chin touch

Table F5
Tooth & TMJ Force Measurements for Drop Tests Onto Lower Front o
Plastic Full Cage Faceguard
Medium Head Wearing TMJ Mouthguard
5/13/93 Data

Drop Ht. Ht-In	1	2	3	5	6	7	SI	G
36	40	44	48	44	49	33	88	36
36	42	69	54	44	77	68	105	36
36	58	83	55	43	90	83	110	36
Average	47	65	52	44	72	61	101	36
Std. Dev.	10	20	4	1	21	26	12	0

peak resultant TMJ force either side = 98 lb, based on average

48	142	150	68	60	158	158	**	60
48	132	149	68	56	146	148	250	59
48	132	148	73	58	146	142	260	61
Average	135	149	70	58	150	149	255	60
Std. Dev.	6	1	3	2	7	8	7	1

peak resultant TMJ force either side = 211 lb, based on average

60	158	177	95	73	173	167	427	80
60	144	142	82	64	131	138	379	74
60	158	167	83	64	164	159	462	93
Average	153	162	87	67	156	155	423	82
Std. Dev.	8	18	7	5	22	15	42	10

peak resultant TMJ force either side = 222 lb, ave; guard hit chin

Force Transducer Locations On Mandible

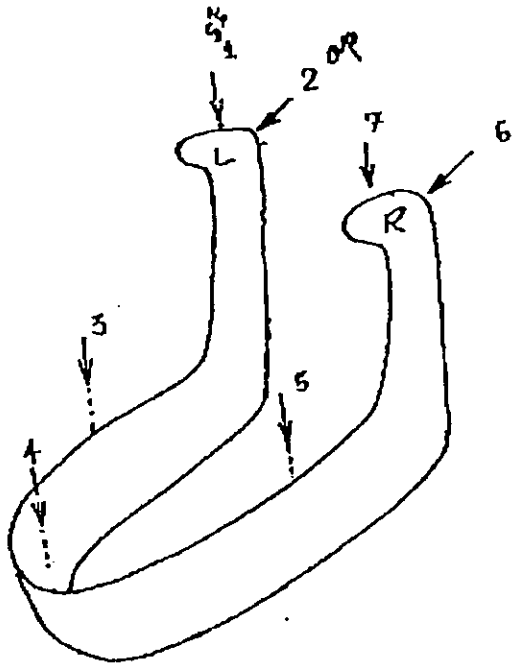

Table F2

Tooth & TMJ Force Measures for Drop T Tests Onto Lower Front of Steel Full Cage Faceguard

Medium Head With Custom Boil & Bite Mouthguard

5/17/93 Data

Drop Ht.	Force Transducer Location								
Ht-in	1	2	3	4	5	6	7	SI	G
36	205	132	21	10	24	135	192	263	70
36	210	126	35	12	49	125	188	265	71
36	225	128	41	10	56	130	200	280	74
Average	213	129	32	11	43	130	193	269	72
Std. Dev.	10	3	1	1	17	5	6	9	2
peak resultant TMJ force either side = 249 lb, based on average									
48	245	140	31	15	40	160	226	375	78
48	250	166	20	10	13	170	228	360	77
48	230	160	20	10	15	170	216	306	70
Average	242	155	24	12	23	167	223	347	75
Std. Dev.	10	14	6	3	15	6	6	36	4
peak resultant TMJ force either side = 287 lb, based on average									
60	590	350	20	10	15	395	630	1364	203
60	400	268	25	10	15	335	456	823	138
60	575	368	20	15	15	400	584	1576	212
Average	522	329	22	12	15	377	557	1254	184
Std. Dev.	106	53	3	3	0	36	90	388	40
peak resultant TMJ force either side = 673 lb, ave; guard hit chin									

Table F4

Tooth & TMJ Force Measures For Drops Onto Lower Front of Steel Full Cage Faceguard

Medium Head With Standard Boil & Bite Mouthguard

5/13/93 Data

Drop Ht.	Force Transducer Location							
Ht-In	1	2	3	5	6	7	SI	G
36	240	139	21	14	134	211	319	75
36	265	153	21	15	146	234	356	82
36	260	145	23	15	141	229	336	77
Average	255	146	22	15	140	225	337	78
Std. Dev.	13	7	1	1	6	12	19	4

peak resultant TMJ force either side = 294 lb, based on average

48	475	274	30	25	269	447	776	142
48	365	225	25	22	212	319	560	108
48	470	265	27	24	261	435	710	137
Average	437	255	27	24	247	400	682	129
Std. Dev.	62	26	3	2	31	71	111	18

peak resultant TMJ force either side = 506 lb, ave; guard hit chin

Table F6

Tooth & TMJ Force Measurements for Drop Tests Onto Lower Front o
Steel Full Cage Faceguard
Medium Head Wearing TMJ Mouthguard

Drop Ht.	Force Transducer Location								Peak
inch	1	2	3	4	5	6	7	SI	G
36	90	74	36	10	23	85	100	201	58
36	108	88	36	5	22	99	115	239	62
36	118	96	36	8	21	107	125	256	66
Average	105	86	36	8	22	97	113	232	62
Std. Dev.	14	11	0	3	1	11	13	28	4
peak resultant TMJ force either side = 149 lb, based on average									
48	176	138	42	6	28	154	181	400	84
48	208	163	39	9	25	180	207	480	93
48	214	166	40	8	26	181	207	498	94
Average	199	156	40	8	26	172	198	459	90
Std. Dev.	20	15	2	2	2	15	15	52	6
peak resultant TMJ force either side = 262 lb, based on average									
60	362	273	52	12	33	277	329	845	131
60	372	285	55	8	39	272	316	922	139
60	386	304	55	8	41	276	323	954	143
peak resultant TMJ force either side = 491 lb, ave; guard hit chin									