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F/FB-111 EJECTION EXPERIENCE (1967-1980)

Part 1. Evaluation and Recommendations

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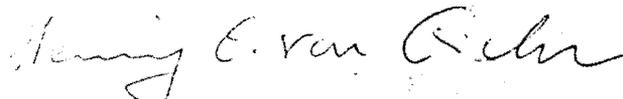
TECHNICAL REVIEW AND APPROVAL

AFAMRL-TR-81-113

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A review of the accident investigation reports of all non-fatal F/FB-111 ejections which occurred from 19 October 1967 to 26 March 1980 was conducted. The available spinal radiographs of the ejectees were also reviewed. The overall vertebral fracture rate among survived ejectees in a properly functioning module was found to be 29.5% (23 of 78). There was no correlation of these fractures with negative inertia reel strap angles. Five radiologic and orthopedic consultants did not agree on the specific mechanism of vertebral fracture in the		

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involved crewmembers. A significant reduction in the vertebral fracture rate appears achievable only by decreasing the acceleration stresses imposed on the crewmembers during landing impact. ↗

PREFACE

This report was prepared by members of the Biodynamics and Bioengineering Division of the Air Force Aerospace Medical Research Laboratory (AFAMRL) in response to a request from the Life Support Systems Program Office of the Aeronautical Systems Division. The report formed the basis for the official AFAMRL position and recommendations regarding the F/FB-111 ejection experience. Detailed summaries of each ejection experience are provided in Part 2 of this report which is published for limited distribution to U.S. Government agencies only (AFAMRL-TR-81-114, Part 2: Summary of Accident Investigation Reports).

The F/FB-111 accident investigation reports were provided for review by the Air Force Inspection and Safety Center (AFISC). The assistance provided by AFISC and the radiologic consultations provided by Drs. R. Levine, V. Ferrari, J. Frymoyer, H. Farfan, and H. Thomas are gratefully acknowledged. Significant contributions to this report were made by Drs. L. Kazarian and A. Barson, Jr., who actively participated in the data collection and analysis, but elected not to endorse all of the conclusions and recommendations presented.

This work was accomplished under project 7231, "Biomechanics of Air Force Operations: Effects of Mechanical Force on Air Force Personnel".

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INTRODUCTION

OBJECTIVES

An examination of the F/FB-111 accident ejection data was undertaken to (1) update the vertebral injury statistics, (2) assess the effectiveness of the T.O. (crossed-arms) bracing procedure, and (3) evaluate the role of negative shoulder harness angles in the etiology of vertebral injuries experienced operationally.

BACKGROUND

The impact acceleration environment experienced during emergency escape in the F/FB-111 crew module is described in AFAMRL-TR-80-52 (Brinkley *et al.*, 1980). An earlier review of the accident ejection data from 19 October 1967 to 30 June 1977 is documented in AMRL-TR-77-60 (Kazarian, 1977), which (1) indicates the relatively high incidence of spinal vertebral fractures among F/FB-111 ejectees, (2) describes the unique, mid-thoracic distribution and the radiographic characteristics of these fractures, and (3) provides a spinal injury mechanism assessment.

MATERIALS AND METHODS

ACCIDENT INVESTIGATION REPORT REVIEW

Materials Available

The complete accident investigation report was reviewed for 15 ejections (ejections 34-48, inclusive). Partial accident investigation reports were reviewed for 27 ejections. For these reports, the sections reviewed included (1) a summary of the mishap, (2) the investigation results, analysis, and recommendations of the Accident Board, (3) testimony of witnesses, and (4) the life sciences section. For one accident (ejection No. 6), only the AF Form 711gA was available for review. For the first seven fatal ejections, only summaries of the accident reports were reviewed.

Review Procedure and Data Presentation

Each accident report was carefully and thoroughly reviewed and all pertinent information which could be obtained from the accident report was recorded on data sheets. Then, a narrative summary of the salient aspects of each accident report was dictated and transcribed. These accident summaries contain the relevant objective information which appears in each accident report and are published in Part 2 of this report (Hearon, 1981) as a limited distribution document.

The available clinical and radiographic data from each accident in which there was a question of a vertebral injury were discussed in detail by the authors of this report and Drs. L. Kazarian and A. Barson, Jr. The results of this effort are summarized in Tables 1, 2, and 3. The Appendix contains a more detailed summary of crewmember vertebral injuries and the criteria used to establish the data base (Table 4) and a more detailed summary of crewmember compliance with the ground landing impact bracing procedure, Technical Order 1F-111F-ISS-39 (Table 5).

Limitations of Review Process and Data Base

The amount of information detailing the escape sequence available in some accident reports is limited. For example, there is often little or no crewmember testimony concerning the retraction, ejection, descent, or ground landing impact phases of the escape, since the majority of questions posed by members of the Accident Investigation Board concern the pre-ejection events that may have caused the mishap. However, many other reports contain surprisingly detailed information regarding the ejection sequence.

Although a full complement of complete accident reports was not available, this was not a serious limitation, since the critical portions of all accident reports were reviewed. The quality of individual accident reports varied widely. In some reports, the flight surgeon, for example, did not assign a particular injury to a specific phase of the escape sequence. Finally, the quality of any data base derived from a review of this type is a function of the thoroughness, objectivity, and aeromedical insight of the reviewer. Notwithstanding these limitations, the F/FB-111 accident investigation reports reviewed have contained useful data on the F/FB-111 ejection experience.

X-RAY REVIEW

Materials Available

Sets of x-ray films of 24 F/FB-111 crewmember ejectees were available for review within AFAMRL. These spinal x-rays were often suboptimal in quality, were not accompanied by pre-injury films, or were long-term follow-up films taken several years following the ejection.

Review Procedure

Selected x-rays from each set of films were presented to several orthopedic and radiologic consultants for their interpretations. These consultants included: R. Levine, M.D. (Orthopedics), V. Ferrari, M.D. (Radiology and Aerospace Medicine), J. Frymoyer, M.D. (Orthopedics), H. Farfan, M.D. (Orthopedics), and H. Thomas, M.D. (Radiology). The specialty in which each consultant is Board certified is designated in parentheses. Drs. Frymoyer and Farfan reviewed the radiographs independently and then submitted a joint report in which they reached a consensus of opinion on the radiographic findings and mechanisms of vertebral fracture.

For consultants Frymoyer, Farfan, and Thomas, each set of films was accompanied by a short clinical history of the crewmember. In the Appendix, Table 6 indicates the mechanism of injury each consultant considers to be responsible for the spinal radiographic findings of each crewmember and delineates the differences of opinion among the consultants regarding the mechanism of injury.

Spinal Degradation Effects

Long-term follow-up spinal x-rays are available for only a few F/FB-111 ejectees. Therefore, long-term spinal sequelae (spinal degradation effects) of ejection from the F/FB-111 cannot be assessed. A long-term follow-up program of ejectees and similar follow-up of an appropriate control group is required for this assessment to be possible. At this time, no such program exists.

RESULTS AND CONCLUSIONS

VERTEBRAL FRACTURES

F/FB-111 Vertebral Injury Statistics

The following tables summarize the F/FB-111 accident ejection data from 19 October 1967 to 26 March 1980, inclusive.

TABLE 1. GENERAL F/FB-111-ACCIDENT DATA

	<u>Number of</u>	
	<u>Aircraft</u>	<u>Crewmembers</u>
Total Ejections	50	100
Non-fatal Ejections	40	80
Non-fatal Ejections with Proper Module Function	39*	78*

TABLE 2. SUMMARY OF F/FB-111 VERTEBRAL FRACTURE DATA

	<u>Pre-T.O.</u>	<u>Post-T.O.</u>
Survived Ejectees	42	36*
No Vertebral Fracture due to Emergency Escape	31**	24
Vertebral Fracture		
a. Ret/Retraction-Ejection	3	6
b. Ground Landing	8	3*
c. Unknown Cause	0	3
Other	5**	0

* One accident (ejection No. 38) was eliminated from the data base. During this accident, the module suspension system failed and resulted in a near vertical ground landing impact of the module. Both crewmembers incurred vertebral fractures on ground landing impact.

** The five crewmembers listed in the "Other" category are also included under "No Vertebral Fracture". (See explanation in text.)

In Table 2, vertebral compression fractures are categorized as having occurred before or after implementation of the T.O. (crossed-arms) bracing procedure as well as during either the retraction-ejection phase or ground landing impact phase of the escape sequence. It was not possible to distinguish retraction injuries from ejection injuries. Therefore, injuries occurring during either phase are reported in the same category. Other injuries which definitely occurred could not be characterized as having occurred during either retraction-ejection or ground landing impact. These injuries are listed under "Unknown Cause".

Of the five crewmembers listed in the "Other" category, three had long-term follow-up x-rays available for review. (See Table 4.) These radiographs, some of which were suboptimal, were interpreted by some consultants as being consistent with vertebral fracture, while other consultants believed the x-rays revealed no vertebral fracture. There was evidence that these three crewmembers had back pain during escape, but all had normal immediate post-ejection spinal radiographs. For the remaining two crewmembers in this category, no x-rays were available for this review. These two crewmembers, previously reported as injured (Kazarian, 1977), had no back pain during escape and one had normal post-ejection spinal radiographs. In this study, the data available for these five crewmembers are not considered to be diagnostic of vertebral fracture resulting from emergency escape. Accordingly, these crewmembers are not recorded as having definitely incurred injuries as a result of ejection from the F/FB-111 aircraft.

Therefore, Table 2 indicates that (1) the pre-T.O. spinal injury rate is 26% (11/42), (2) the post-T.O. spinal injury rate is 33% (12/36), and (3) the overall spinal injury rate is 29.5% (23/78). These data exclude ejection No. 38, as indicated above. (If any or all of the five crewmembers in the "Other" category in Table 2 were in fact injured, the pre-T.O. vertebral fracture rate would then range from 26 to 38%, the post-T.O. rate remains unchanged at 33%, and the overall vertebral fracture rate would range from 29.5 to 36%.)

This presentation of the F/FB-111 vertebral injury data differs from F/FB-111 data previously reported (Kazarian, 1977) in two respects. First, Table 2 is firmly based on clinical correlation of the radiographic findings and categorizes the vertebral fractures according to when they occurred in the escape sequence. Second, the current data base does not liberalize the definition of vertebral fracture to include those diagnoses made on the basis of long-term follow-up x-rays. Although some vertebral fractures may not be diagnosed by x-rays until weeks following the injury (Epstein, 1976), the incidence of trauma-related radiographic vertebral abnormalities in this type of population (Feldman 1979; Hearon et al., 1981; Hilton et al., 1976; and Resnick et al., 1978) makes it difficult to attribute nonspecific radiographic findings, that may be observed on long-term follow-up x-rays of the ejectees, to the specific remote trauma of ejection. This second difference largely accounts for the lower overall vertebral fracture rate reported in this study.

Mechanism of Vertebral Injury

Pertinent references on vertebral fracture mechanisms include: Burke, 1971; DeOliveira, 1978; Epstein, 1976; Holdsworth, 1963; Holdsworth, 1970; Nicoll, 1949; Kaufer, 1975; Kazarian, 1977; and Zatzkin, 1965.

Retraction-Ejection Injuries

Nine of the 23 injured crewmembers were apparently injured during retraction-ejection (Table 2). Review of the accident ejection data has revealed that one of these crewmembers (see ejection No. 13) was apparently injured when his shoulders contacted the bottom of the headrest during retraction. The mechanism responsible for the other eight injuries is open to speculation. One of these crewmembers (see ejection No. 30) may have been injured by the horsecollar mechanism (Brinkley et al., 1980).

The potential for hyperextension during inertia reel retraction in the F/FB-111 and for combined hyperextension-hyperflexion injuries among ejectees has been proposed (Kazarian, 1977). Radiologic and orthopedic consultants, however, do not agree on the specific mechanism of spinal injury (extension, flexion, axial compression, rotation) responsible for the spinal radiographic findings of the involved crewmembers. (See Table 6 in the Appendix.) In addition, based on a review of the F/FB-111 x-rays, the radiographic criteria which are diagnostic of vertebral fracture, and the medical literature on vertebral fracture, one of us (B.H.) does not believe that a hyperextension mechanism is responsible for retraction-ejection injuries.

Notwithstanding this difference of opinion regarding the potential for hyperextension, the potential for flexion during retraction-ejection is well-recognized. The retraction-ejection histories provided by ten crewmembers, four of whom were apparently injured during retraction-ejection indicate that significant spinal flexion is possible during this phase of the escape sequence.

Ground Landing Impact Injuries

Eleven of the 23 injured crewmembers were apparently injured during ground landing impact. The mechanism responsible for these injuries is axial compression and flexion. Of the 78 crewmembers who successfully ejected from the F/FB-111 aircraft in a properly functioning module, 46 reported ground landing impact as being severe, more severe than anticipated, or relatively more severe than retraction-ejection. On the other hand, 16 of 78 crewmembers reported retraction-ejection as being severe, more severe than anticipated, or relatively more severe than ground landing impact.

Review of the early F/FB-111 accident investigation reports clearly indicates that the severity of ground landing impact was recognized as a problem in the late 1960's. Brinkley *et al.* (1980) stated that a significant reduction in the spinal injury rate appears achievable only by decreasing the acceleration stresses imposed on crewmembers during ground landing impact. The unique, combined accelerations imposed on the crewmember during ground landing impact may be responsible for the relatively high incidence of vertebral fractures observed operationally and, further, may be responsible for the unique (mid-thoracic) distribution and the characteristics of the spinal injuries observed.

Correlation of Spinal Injuries with Negative Shoulder Harness Angles

To date, there has been no correlation of the F/FB-111 vertebral fractures with shoulder harness angles. These angles are a function of crewmember build (weight), sitting height, mid-shoulder sitting height, seat pan horizontal adjustment, seat vertical adjustment, and headrest adjustment. This type of operational data for the injured crewmembers is fragmentary. Previous theories regarding the role of negative shoulder harness angles in the operational injuries observed (retraction-ejection and ground landing impact injuries) are based on the potential for negative shoulder harness angles for some crewmembers in some seat configurations in the operational system. Negative shoulder harness angles in the fully restrained position are to be avoided according to the applicable military specification, Mil-Spec-C-2596B(USAF).

In order to evaluate the influence of negative shoulder harness angles in the operational F/FB-111 crew seat and restraint system, three investigative efforts are currently in progress.

An investigation has been initiated to assess the influence of negative shoulder harness angles in the operational system on human biodynamic response during +G_z impact accelerations (10 G peak, 25-30 ft/sec velocity change). In addition, the entire range of shoulder harness angles possible will be documented as a function of seat and headrest adjustments for each human volunteer subject.

Another investigation has been initiated to study the potential for vertebral injury of human cadaveric subjects exposed to ballistic inertia reel retraction in the operational system.

Biodynamic model calculations continue to simulate the retraction forces and resultant spinal loading possible in the operational system.

T.O. BRACING PROCEDURE (T.O. 1F-111F-1SS-39)

Background

This bracing procedure was implemented on 13 October 1975 in an effort to minimize forward displacement of the head and, in turn, the upper torso during ground landing impact of the F/FB-111 crew module. Prior to implementation of the T.O. brace, a passive hands-in-lap ground landing impact position was recommended.

T.O. Compliance

Table 3 summarizes the T.O. compliance data. The rate of full T.O. compliance is 50%. Specific reasons for partial compliance or non-compliance are indicated for each crewmember in Table 5 (Appendix). Factors influencing the degree of T.O. compliance include (1) insufficient time to comply, (2) physical difficulty complying, and (3) non-familiarity with the technique or its proper execution. (See Table 5.)

TABLE 3. SUMMARY OF T.O. COMPLIANCE DATA

	<u>Post-T.O.</u>	<u>T.O. Compliance</u>		
		<u>Full</u>	<u>Partial</u>	<u>None</u>
Survived Ejectees	36	18	6	12
No Vertebral Fracture	24	11	4	9
Vertebral Fracture				
a. Ret/Ret-Ejection	6	3	1	2
b. Ground Landing	3	2	1	0
c. Unknown Cause	3	2	0	1

Effectiveness of the T.O. Bracing Procedure

There is no statistical evidence to indicate that the T.O. brace has been effective or ineffective in altering the rate of spinal vertebral fracture on ground landing impact. This assessment may be complicated by the following considerations. First, flexion vertebral fractures which ostensibly occurred on ground landing impact may, in fact, have occurred during retraction-ejection. Injuries occurring during retraction-ejection obviously cannot be prevented by bracing procedures intended to avert landing impact injuries. Second, an increased awareness of the relatively high incidence of vertebral fractures among F/FB-111 ejectees has led to heightened surveillance among members of the aeromedical community and thus a greater likelihood of diagnosing a vertebral fracture, if one exists.

RECOMMENDATIONS

The F/FB-111 vertebral fracture categorization presented in this report should replace the previous method of classification of these injuries. Clarification of whether retraction injuries can occur separate from ejection injuries is desirable.

A test program to evaluate the influence of negative inertia reel strap angles in the operational F/FB-111 crew seat and restraint system on human biodynamic response during $+G_z$ and $-G_x$ ("eyeballs out") impact accelerations should be considered.

Surviving F/FB-111 ejectees should continue to be carefully screened for vertebral injuries. It may be helpful to include radionuclide bone scanning in the post-ejection medical evaluation to establish the presence or absence of vertebral fracture.

A test program to comparatively evaluate the T.O. bracing position and proposed alternate bracing techniques during $+G_z$ and combined $+G_z$, $-G_x$ impact accelerations should be considered.

A decision regarding continued use of the T.O. bracing position should be deferred until data from the comparative test program recommended above is obtained and analyzed.

The AF Form 711gA should be altered to accommodate critical F/FB-111 ejection data, such as seat vertical, seat pan horizontal, and headrest adjustment.

REFERENCES

- Brinkley, J., J. Raddin, Jr., B. Hearon, L. McGowan, and J. Powers, 1980. Evaluation of a Proposed, Modified F/FB-111 Crew Seat and Restraint System, AFAMRL-TR-80-52, Air Force Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio.
- Burke, D., February 1971, "Hyperextension Injuries of the Spine", Journal of Bone and Joint Surgery, Vol. 53B, No. 1.
- DeOliveira, J., June 1978, "A New Type of Fracture-Dislocation of the Thoracolumbar Spine", Journal of Bone and Joint Surgery, Vol. 60-A, No. 4.
- Epstein, B., 1976, The Spine: A Radiological Text and Atlas, Edition IV, Lea and Febiger, Philadelphia.
- Feldman, F., January 1979, "Miscellaneous Localized Conditions: A Whirlwind Review of the 'Oh My Aching Back' Syndrome", Seminars in Roentgenology, Vol. 14, No. 1.
- Hearon, B. and J. Raddin, Jr., March 1981, "Experience With Highly Selective Screening Techniques for Acceleration Stress Duty", AGARD-CP-310.
- Hearon, B., 1981, F/FB-111 Ejection Experience (1967-1980) - Part 2: Summary of Accident Investigation Reports, AFAMRL-TR-81-114, Air Force Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio.
- Hilton, R., J. Ball, and R. Benn, 1976, "Vertebral End-Plate Lesions (Schmorl's Nodes) in the Dorsolumbar Spine", Annals of the Rheumatic Diseases, Vol. 35.
- Holdsworth, F., February 1963, "Fractures, Dislocations, and Fracture-Dislocations of the Spine", Journal of Bone and Joint Surgery, Vol. 45B, No. 1.
- Holdsworth, F., December 1970, "Fractures, Dislocations, and Fracture-Dislocations of the Spine," Journal of Bone and Joint Surgery, Vol. 52-A, No. 8.
- Kaufer, H., 1975, "Part 2: The Thoracolumbar Spine", in Fractures, Vol. 2, C. Rockwood, Jr. and D. Green, eds., J. B. Lippincott Co., Philadelphia.
- Kazarian, L., October 1977, F/FB-111 Escape Injury Mechanism Assessment, AMRL-TR-77-60 (AD A052337), Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio.
- Nicoll, E., August 1949, "Fractures of the Dorso-Lumbar Spine", Journal of Bone and Joint Surgery, Vol. 31B, No. 3.
- Resnick, D., and G. Niwayama, January 1978, "Intravertebral Disk Herniations: Cartilaginous (Schmorl's) Nodes", Diagnostic Radiology, Vol. 126.
- Zatzkin, H., 1965, The Roentgen Diagnosis of Trauma, Year Book Medical Publishers, Inc., Chicago.

APPENDIX

TABLE 4. DETAILED SUMMARY OF CREWMEMBER VERTEBRAL FRACTURE DATA

A detailed summary of the F/FB-111 crewmember vertebral fracture data is provided in Table 4. All crewmembers who definitely incurred a vertebral fracture or for whom there was a question of a vertebral fracture are included in the table. Each ejection is designated by a number. Each ejectee is designated by the ejection number and a letter indicating the crew station he occupied at the time of ejection. Details of each ejection are provided in Part 2 of this report.

Subjective: Onset of Back Pain

Retraction/Retraction-Ejection

An "X" under "R/R-E" indicates that the crewmember provided a history of back pain beginning during retraction-ejection.

A "?" under "R/R-E" indicates that the crewmember may have provided a history of back pain beginning during retraction-ejection. (In these cases, a positive history for pain was assumed on the basis of a diagnosis of a paravertebral muscle strain attributed to retraction-ejection on the 711gA.)

Ground Landing Impact

An "X" under "GLI" indicates that the crewmember provided a history of back pain beginning during ground landing impact.

A "?" under "GLI" indicates that the crewmember may have provided a history of back pain beginning during ground landing impact. (In these cases, a positive history for pain was assumed on the basis of a diagnosis of a paravertebral muscle strain attributed to ground landing impact on the 711gA.)

Objective: Fracture by X-ray Diagnosis

An "X" under "Fx by X-ray" indicates that there is radiographic evidence of a vertebral fracture for that crewmember and that the injury is definitely attributable to ejection from the F/FB-111 aircraft.

An "*" under "Fx by X-ray" indicates that the available radiographic evidence described under "Remarks" is not considered to be diagnostic of vertebral fracture in this study. Therefore, these crewmembers are not considered to have been injured as the result of ejection from the F/FB-111 aircraft. (See discussion in body of report.)

AFAMRL Concensus - Fracture Attributed to:

Retraction/Retraction-Ejection

An "X" under "R/R-E" indicates that the vertebral fracture probably occurred during retraction-ejection.

A "?" under "R/R-E" indicates that the vertebral fracture may have occurred during retraction-ejection.

Ground Landing Impact

An "X" under "GLI" indicates that the vertebral fracture probably occurred during ground landing impact.

A "?" under "GLI" indicates that the vertebral fracture may have occurred during ground landing impact.

Unknown Cause

An "X" under "Unkn" indicates that the vertebral fracture definitely occurred, but the fracture could not be attributed with certainty to either retraction-ejection or ground landing impact.

CREWMEMBER	SUBJECTIVE Back Pain		OBJECTIVE Fx by X-ray	AFAMRL CONCENSUS Fx Attributed to			REMARKS
	R/R-E	GLI		R/R-E	GLI	Unkn	
2-R		X	X	?	X		Injury likely on GLI. Injury possibly on R/R-E
4-R	X		X	X	?		Injury likely on R/R-E. Injury possibly on GLI.
5-L		X	X		X		
6-R		?	*				10-year post-ejection x-rays.
11-L		?	*				3-year post-ejection x-rays.
13-L	X		X	X			
15-L			*				No x-rays available.
19-L	X		*				7-year post-ejection x-rays.
20-R			*				No x-rays available.
23-L		X	X		X		
23-R		?	X		X		Diagnosis by 10-month follow-up x-rays.
26-L		X	X		X		
27-L	X	X	X	X	?		Injury likely on R/R-E. Injury possibly on GLI.
27-R		?	X		X		
28-L		X	X		X		
28-R		X	X		X		
29-L	X		X	X			
30-L	X		X	X			
32-L			X			X	
32-R	?		X	X			
34-R		X	X		X		
36-L	X		X	X			
36-R			X			X	New diagnosis from concensus of consultants on immediate post-ejection x-rays.
38-L			X		X		Injury on GLI as result of suspension line failure.
38-R		X	X		X		Injury on GLI as result of suspension line failure.
39-R		X	X		X		
43-L	X		X	X	?		Injury likely on R/R-E. Injury possibly on GLI.
43-R	?		X	X	?		Injury likely on R/R-E. Injury possibly on GLI.
45-R		?	X		X		
48-R			X			X	

TABLE 5. DETAILED SUMMARY OF F/FB-111 T.O. COMPLIANCE DATA

A detailed summary of the T.O. compliance data for each crewmember who has ejected since the T.O. was implemented is provided in Table 5. Each ejection is designated by a number. Each ejectee is designated by the ejection number and a letter indicating the crew station he occupied at the time of the ejection. Details of each ejection are provided in Part 2 of this report.

An "X" under "Full" indicates that the crewmember actually or likely complied fully with all aspects of the T.O. bracing procedure (including seat pan adjustment, feet on rudder pedals, and crossing arms).

An "X" under "Partial" indicates that the crewmember partially complied with the T.O. bracing procedure. In all of these cases, the crewmembers employed the crossed-arms brace, but did not comply with some other aspect of the bracing technique. The reason for partial compliance is indicated under "Remarks".

An "X" under "None" indicates that the crewmember did not cross his arms. Other reasons for T.O. non-compliance are indicated under "Remarks". All of these crewmembers are considered non-compliers with the T.O. bracing procedure.

An "X" under "Difficulty" indicates that the crewmember had physical difficulty complying with the brace for the reason indicated under "Remarks".

CREWMEMBER	T.O. COMPLIANCE			DIFFICULTY	REMARKS
	FULL	PARTIAL	NONE		
29-L			X		Did not adjust seat pan. Feet on floor.
29-R			X		Feet on floor.
30-L			X		Forgot crossed-arms brace.
30-R	X				
31-L			X		Insufficient time.
31-R			X		Insufficient time. No training (personal communication).
32-L			X		Insufficient time. Pinched helmet between elbows.
32-R			X		No reason for non-compliance.
33-L			X	X	Could not adjust seat pan.
33-R		X			Did not adjust seat pan forward. Insufficient time (?)
34-L			X		Attempted to comply incorrectly. Pinched head between elbows.
34-R		X			Did not adjust seat pan forward.
35-L	X				
35-R	X				
36-L		X			Wedged legs against instrument panel.
36-R	X				
37-L			X		Insufficient time. Attempted to grasp headrest.
37-R			X	X	Could not adjust seat pan. No training (personal communication).
38-L					Eliminated from data base due to suspension system failure.
38-R					
39-L	X				
39-R	X				
40-L	X				
40-R	X				
41-L	X				
41-R	X				
43-L	X				
43-R	X				
44-L	X			X	Difficulty reaching shoulder straps.
44-R		X		X	Difficulty crossing arms. Oxygen mask off. Feet on floor.
45-L	X				
45-R	X				
46-L	X				
46-R			X		Placed hands on shoulders.
47-L		X			Removed oxygen mask.
47-R		X			Removed oxygen mask.
48-L	X				
48-R	X				

TABLE 6. SUMMARY OF CONSULTANTS' RADIOGRAPHIC INTERPRETATIONS

A summary of the results of the independent x-ray consultations obtained is provided in Table 6. Each ejection is designated by a number. Each ejectee is designated by the ejection number and a letter indicating the crew station he occupied at the time of ejection. Details of each ejection are provided in Part 2 of this report. The differences of opinion which the consultants have regarding the mechanism of vertebral fracture for a given crewmember are clearly indicated. The abbreviations used in this table include the following.

"E" indicates a hyperextension mechanism.

"F" indicates a hyperflexion mechanism.

"AC" indicates an axial compression mechanism.

"R" indicates rotation.

"T" indicates torsion.

"L" indicates lateral.

"LR" indicates lateral rotation.

"?" indicates uncertainty in the mechanism of fracture.

"No" indicates that no injury could be diagnosed on the basis of the available x-rays.

"NC" indicates that no comment was made about the x-rays (poor film quality).

No designation indicates that no x-rays of the crewmember were reviewed by that consultant.

Combined mechanisms are indicated by a combination of the appropriate abbreviations listed above.

CREWMEMBER	CONSULTANTS			
	<u>Dr. Levine</u>	<u>Dr. Ferrari</u>	<u>Drs. Frymoyer and Farfan</u>	<u>Dr. Thomas</u>
2-R		E-F		
4-R	F	F-R	AC-F(?)	AC-F
6-R	F	(?)	AC	AC
11-L	F	No	F	No
13-L	E-F	AC(?)	AC	AC
19-L	E	No		
23-L	E-F	E-F/F*	AC-R	F-AC
23-R		E		
26-L	F	E-F	AC	F
27-L	E-F	E-F	AC	F
27-R		E		
28-L	E-F-R	E-F	F-R	F-AC
28-R	E-F	E-F	F-R	AC-F
29-L		E		
30-R	E-F	E(F?)	AC	AC-F
32-R	F		AC-F	F
34-R	E-F	F(?)	AC-F(?)	F
36-L	E-F	E	AC,L	AC-F
36-R	F	F	AC-T	F-R
38-L	AC-F		F-R	AC-F
38-R			AC-F	AC-F
39-L	E(?)	E-R-AC	No	No
39-R	E-LR		No	F-R
40-L	NC	No	F	No
43-L	F	T	AC	F-R
43-R	E-F	E-F	AC	F
45-R	E-F	E-F	AC	AC-F
48-R	E-F	AC	AC	No

* Two differing interpretations by the same consultant.