Axial injury tolerance of the clavicle and the effect of age, gender and boundary conditions

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ABSTRACT

Although clavicle biomechanical response under axial loading was studied by a number of researchers, no injury criteria has been established. An injury criterion could help interpret the results from anthropometric test device and human clavicle finite element modeling. Therefore, the goal of this study is to construct a database of clavicle axial loading response, develop an injury criterion for clavicle under axial loading and study the effect of parameters such as age, gender, loading rate, aspect(right vs left), boundary condition on clavicle injury risk. Four clavicles were loaded to failure under axial loading configurations at loading rate of 1m/s to further expand the current available clavicle failure data in literature. Then a database of 68 clavicle specimens under axial loading failure was compiled. A multivariate Weibull survival analysis was performed with this database to obtain the clavicle injury risk criterion under axial loading. It was found that the clavicle injury risk decreases as the age increase until 56 years old, and then the clavicle injury risk increases as age increases. It was also observed that female subject has a higher clavicle injury risk than male under the same loading condition. The boundary conditions could also change the clavicle injury risk significantly. However, loading rate and aspect (Left VS Right) do not have statistically significant effects on clavicle injury risk in this study.

INTRODUCTION

Clavicle injuries are fairly common during automotive accidents. It was reported that 66% of shoulder injuries during automotive lateral impacts are clavicle fractures (Frampton et al.1997). The susceptibility of the clavicle to injury underscores its role as an important loading path during side impact crashes (Melvin et al.1998), since clavicle is loaded directly through shoulder in lateral impact crashes.

Anthropometric test devices (ATD), such as Euro-SID, have already incorporated clavicle load cells to measure clavicle loading response during side impact tests, however, no injury criterion is available yet to interpret this data in terms of the clavicle injury risk. Clavicle finite element models (FEM) were developed by a number of researchers (e.g. Dalmases et al. 2008; Duprey et al. 2008; Duprey et al. 2010; Li et al. 2012) to study and predict clavicle injuries, but mostly in a deterministic way, which essentially disregard the variability characteristics of biological tissues. An injury criterion that can predict the probability of injury could be more useful for understanding and interpreting both the ATD and FEM results and subsequently help design countermeasures for injury prevention.

In addition, an injury criterion that can predict and discriminate injury risk under different risk factors such as age, gender is more desirable for researchers to design occupant specific countermeasures. The biomechanical response and failure tolerance of the clavicle under axial loading was characterized by several researchers previously. These studies combined together provide a valuable database to study injury threshold of the clavicle, and the effects of parameters such as age, gender, aspect (left VS right), boundary conditions and loading rate on clavicle injury risk.

Therefore, the goal of the current study is: 1) to conduct additional clavicle axial loading tests to expand the available clavicle data set in the literature; 2) to develop an injury risk criterion for the clavicle under axial loading condition, by combining data describing clavicle axial compression loading tolerances from previous literature and current study.

METHODS

1) New experimental data:

The clavicle was prepared and tested following with the same methodology as described in Zhang et al. (2012). Four clavicle specimens extracted from 3 post-mortem human surrogates (PMHS) were tested in this study. After thawing the specimens, all soft tissues were removed. Each clavicle was then measured to determine the length of the clavicle in the medial-lateral direction (Table 1). Each clavicle extremity was potted in a square-shaped aluminum mold with a polyurethane resin. The bone was rotated until the transverse plane of the clavicle was aligned with one face of the potting mold (to ensure that the anterior, superior, posterior, and inferior aspects of the bone were aligned with the mold edges), and the loading was applied within the clavicle major plane(x-z plane) (Figure 1.a).

The test fixture provided a pinned boundary condition at the medial end of the specimen and a fixed (cantilever) boundary condition at the lateral end (Figure 1.b). The medial end was attached to a metal cup which was permitted to rotate about the superior-inferior axis only. The lateral end was clamped to the piston of a servo-hydraulic testing machine to prevent rotation. A 6-axis load cell and a rotational potentiometer were located on the medial end assembly to measure reaction force and rotation of the end. A uni-axial load cell was installed between the actuator and lateral potting block. The actuator was displaced at 1 m/sec to a maximum displacement of 30 mm to ensure gross failure of the specimen.

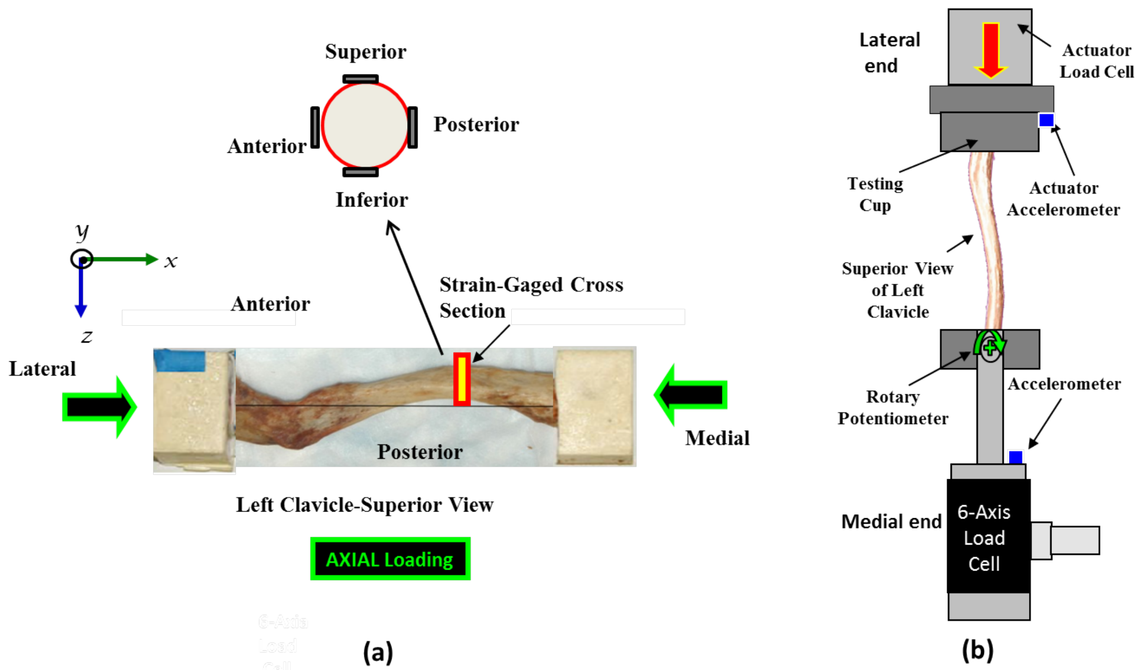

Figure 1: (a) Clavicle potting method in component level test and its loading schematics under axial condition (b) Axial loading test fixture schematic

In addition, four uni-axial strain gages were adhered around the perimeter of the clavicle cross-section at the location of maximum posterior concavity of the clavicle. One gage was positioned on each of the four anatomical aspects of the bone—anterior, superior, posterior, and inferior—with the sensitive axis of the gage aligned with the longitudinal axis of the bone (Figure 1.a). Medium-resolution (~0.25 mm in-plane resolution, 0.625 mm slice thickness) CT scans was then taken of each specimen after the preparation process was completed.

2) Clavicle axial loading database:
A database was compiled from the literature describing clavicle axial loading failure tests and the data in current study. To be included in the database, the tests should be:

1) Part of a peer-reviewed study available in the open literature,
2) Specimen information such as size, age, gender were included,
3) Component level axial loading failure test.

3) Injury risk function development:

Data scaling: to develop the injury risk function, the biomechanical response is typically scaled to a standard subject size to minimize the variability from the subject size. To scale the clavicle force-deflection response, a geometric scaling factor needs to be derived from the physical dimension of the clavicle by assuming geometric similarity of the clavicle specimens. However, considering the complex geometry of the clavicle (S shape and non-prismatic), the validity of this assumption was checked first by performing a Pearson correlation analysis between the different geometric measurements of the clavicles including clavicle length and cross-section properties. More specifically, two questions were investigated: 1) whether there is correlation between the clavicle length and clavicle cross-section properties. This was investigated by correlation analysis between clavicle length and the clavicle cross-section properties at the maximum posterior concavity (Figure); 2) whether there is geometric similarity between the clavicle cross-sectional properties at different locations across the clavicle longitudinal direction. This was investigated by correlation analysis of the cross-sectional properties between the maximum posterior concavity and maximum anterior concavity (Figure 2). These two locations were chosen because it is easily identifiable and failures most often occur in the middle third of the clavicle, making this area of particular interest. Twenty four clavicles (20 from Zhang et al.2012 and 4 from the current study) were used for the correlation analysis in this study. The CT cross-sectional images at the maximum posterior concavity and maximum anterior concavity of each clavicle were identified. The cortical bone, trabecular bone were separated with HU=700 (Hounsfield Unit), then the cross-sectional properties, including the cross-section area, trabecular bone area, cortical bone area, and the area moment of inertia were calculated based on CT images. A correlation analysis was performed with between these measurements.

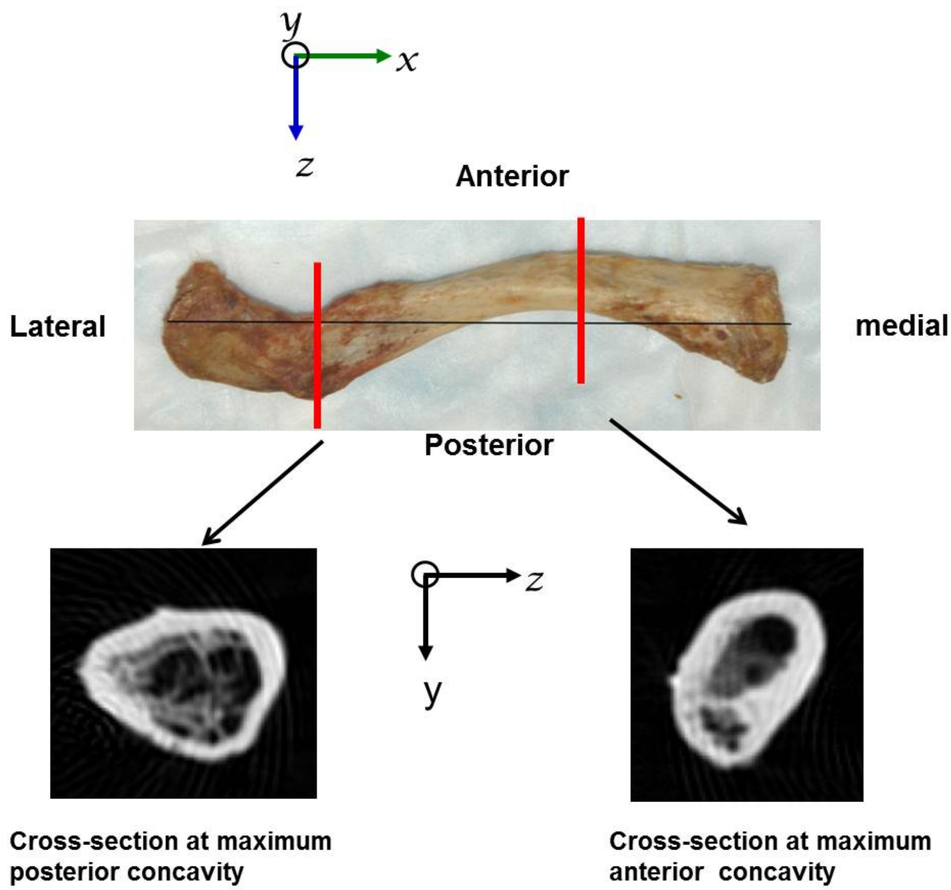

Figure 2. Cross-section at maximum posterior concavity and maximum anterior concavity

Survival analysis: after a proper approach on scaling the clavicle force-deflection response, a Weibull multivariate survival analysis was performed to develop the injury risk function. The regression coefficients were estimated from the injury data points by maximum likelihood estimation method. A number of parameters were investigated as predictor variables in the regression model, including specimen age, gender, aspect (left VS right), loading rate and boundary conditions. From these predictor variables, stepwise model selection scheme was employed to choose the best model based on the Akaike information criterion (AIC) of each model, and the significance of each predictor variable ($p<0.05$).

RESULTS

Reliable data for reaction force, reaction moments, rotations, applied displacement, and strain were obtained for all 4 tests. The force and strain response of a representative clavicle specimen is shown in Figure 3. The vast majority (98% or more) of the reaction force at the medial extremity was directed along the loading axis (FX), and the loader force measured in the clavicle lateral is comparable with the FX in the clavicle medial end (Figure 3 Left). It was also observed that the anterior and posterior strain gauge sustained tensile and compressive strain respectively, although the clavicle under axial compression loading. This is due to the S-shape of the clavicle, which put the cross-section with strain gauge under a loading mode of combined compression and bending. The force-displacement (FX) response of the four clavicles was shown in Figure 4. It was observed that clavicles 473L, 473R, and 480L all had comparable force-deformation responses. Interestingly, the stiffness (i.e. the approximate slope of the force vs. displacement curve) for 468R after about 5 mm of displacement is similar to the stiffness of the other three clavicles; with the only difference being that the toe region (i.e. the initial non-linear region in the curve) is substantially longer for 468R than the others. The failure force and displacement are summarized in Table 1. The average failure force is 2800 ±138 newton, and the average failure displacement is 8.87 ±3.75mm. The failure displacement has a relatively large standard deviation because of the outlier 468R.

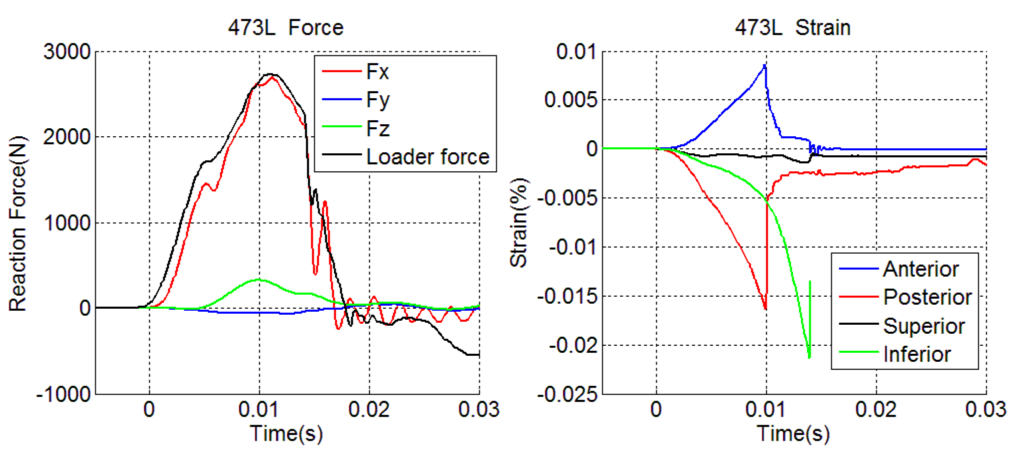

Figure 3 : (Left) clavicle 473L reaction force time history; (Right) clavicle 473L strain time history response

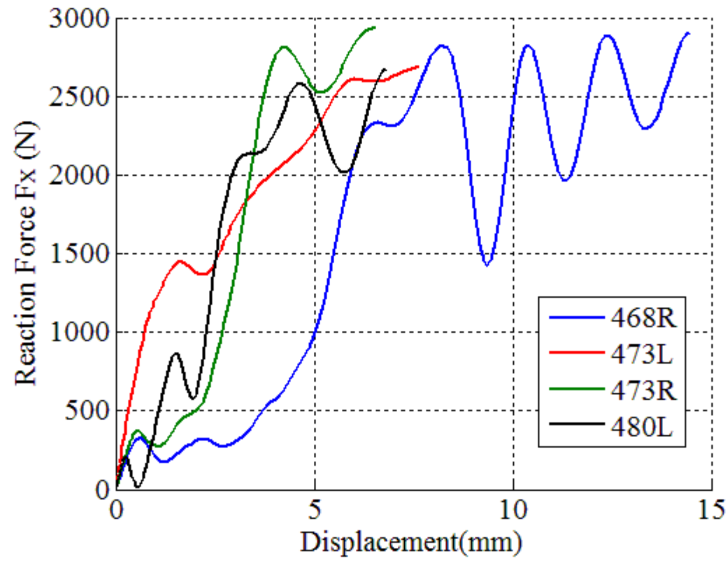

Figure 4: reaction force (FX) VS displacement response.

Table 1: Clavicle Specimen Information and Experiment Results

Specimen ID	PMHS Information				Clavicle experiment results		
	Aspect	Gender	Age (year)	Clavicle Length(mm)	Test Configuration	F_{frac} (N)	D_{frac} (mm)
468	Right	Male	67	151.8	Axial	2906	14.45
473	Left	Male	54	151.5	Axial	2685	7.66
473	Right	Male	54	156	Axial	2934	6.58
480	Left	Male	71	162.5	Axial	2678	6.80
Average	-	-	61 ±8.8	155.5±5.1	-	2800 ±138	8.87 ±3.75

Clavicle axial loading database: six studies that satisfied the above criterion were found, with a total of 68 specimens as shown in
Table **5** in Appendix. They are from Harnroongroj et al.2000, Duprey et al.2008, Dalmases et al.2010 (quasi-static tests), Zhang et al. 2012, Dalmases et al. 2013(dynamic tests) and the current study. This database includes specimens with age ranging from 14 to 86 years old, loading rate ranging from 0.16 mm/s to 2500 mm/s. 15 clavicles are from female subjects while the rest 53 clavicles are from male. Half of the clavicles are from the left side while the other half are from the right side. In terms of the boundary conditions, there are essentially two different boundary conditions: the pin-fixed boundary conditions, and the ball-socket joint boundary conditions.

Data scaling

A correlation matrix between the clavicle length and clavicle cross-sectional properties at the maximum posterior concavity showed that the correlation of clavicle length with the clavicle cross-section properties is very low (Table 2). These indicate that there is a lack of the geometric similarity between the length and the cross-section properties, and the clavicle length may not be an appropriate factor for scaling the clavicle force-deflection response. The correlation analysis of the cross-sectional properties between the anterior maximum concavity and posterior maximum concavity of the clavicle also indicates very low correlation exists between them (Table 3). These results indicate that scaling the clavicle response based on any of the above mentioned geometric measurements may not appropriate in the current study. Therefore, the clavicle axial failure data was not scaled and was used to develop injury risk function directly.

Table 2: correlation matrix between clavicle length and cross-section properties at maximum posterior concavity

	Clavicle length	Cor_CSA	Tra_CSA	CSA	Izz	Iyy	Iyz
Clavicle Length	1	-0.043	-0.217	-0.203	-0.133	-0.162	-0.149
Cor_CSA	-	1	0.103	0.543	0.417	0.592	0.553
Tra_CSA	-	-	1	0.891	0.802	0.773	0.846
CSA	-	-	-	1	0.867	0.922	0.967
Izz	-	-	-	-	1	0.71	0.94
Iyy	-	-	-	-	-	1	0.901
Iyz	-	-	-	-	-	-	1

1) Cor_CSA: cortical bone cross-section area
2) Tra_CSA: trabecular bone cross-section area
3) CSA: total cross-section area
4) Izz: area moment of inertia Z
5) Iyy: area moment of inertia Y
6) Iyz: area moment of inertia YZ

Table 3. Correlation coefficients of the cross-sectional properties between maximum posterior concavity and maximum anterior concavity

Correlation Coefficient	Izz	Iyy	Izy	Cor_CSA	Tra_CSA
	-0.033	0.206	-0.51	0.447	-0.344

Injury risk model development: to develop the clavicle injury risk function, a multivariate Weibull survival model with risk factor including age, gender, loading rate aspect and boundary conditions as potential covariates is shown in equation 1.

$$P(f) = 1 - \exp(\lambda * f^{\gamma}) \quad \text{-------------- (1)}$$

Where f is the predictor variable (in our case f is the applied force),$\lambda = -\exp(-\propto_0 - \propto_1 x_1 - \propto_2 x_2 + \cdots)$, and $x_1, x_2, \ldots$ are covariates such as age, gender and so on, and $\propto_1, \propto_2$ ... are the corresponding coefficients for these covariates.

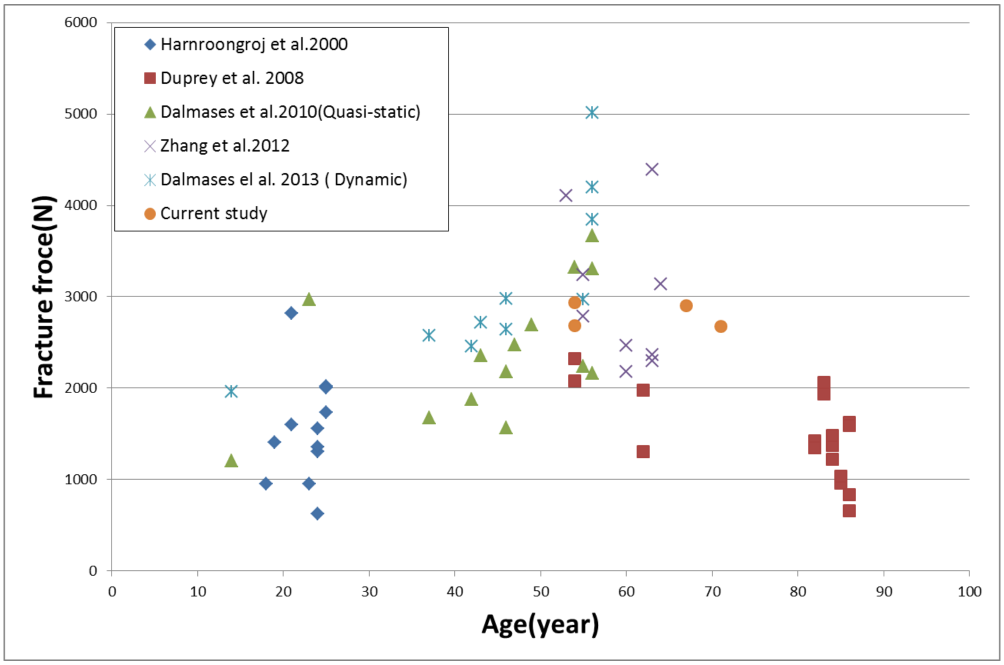

Figure 5: Specimen age VS clavicle failure force

However, initial examining the relationship of age VS fracture force (Figure 5) shows that as age increases, the fracture force increase and then the fracture force decreases. Therefore, a modified Weibull model was proposed in the current study to model this bi-modal effect of age: The Weibull model was modified as a piecewise function for the risk factor age as the following:

$$P(f) = 1 - \exp\left(-\exp\left(-\propto_0 - \propto_{1a}(x_1 - Age_{peak}) - \propto_2 x_2 + \cdots\right) * f^{\gamma}\right)$$

When $age \leq Age_{peak}$

$$P(f) = 1 - \exp\left(-\exp\left(-\propto_0 - \propto_{1b}(x_1 - Age_{peak}) - \propto_2 x_2 + \cdots\right) * f^{\gamma}\right)$$

When $age \geq Age_{peak}$

-------------- (2)

Here x_1 is age, and x_2, x_3 ... are other risk factors including gender, loading rate, aspect and boundary conditions. An additional variable Age_{peak} was introduced here to separate the failure data into two groups. When $age \leq Age_{peak}$, the coefficient for age is $\propto_{1a}$; while when $age \geq Age_{peak}$, the coefficient for age is $\propto_{1b}$. However, it should be noted that coefficients for other potential covariates remain to be the same throughout the whole clavicle sample in the database. Therefore, the maximum likelihood estimates the injury risk function coefficients over the whole database, not fit the model into two age groups separately. In addition, the Age_{peak} was limited between 45-65 according to the plot.

With the stepwise model selection scheme based on the AIC criterion, the best model that fit the clavicle axial loading failure tests data was obtained in equation 3. Age_{peak} was determined to be 56 years old based on the optimization results(with the goal of maximize the model likelihood value). It was also found that both the age gender and boundary conditions are significant predictors of the clavicle injury risk (P<0.05). However, the loading rate and aspect (Left VS Right) were not significant predictors, and therefore were not included in the final injury risk function. The influence of age, boundary condition and gender on clavicle injury risk was illustrated in Figure 6 and Figure 7. Female subject has a higher clavicle injury risk. The clavicle also has a higher injury risk under the ball-socket boundary conditions. Regarding the age, a subject has lowest clavicle injury risk at age around 56. And the injury risk decreases as the age is getting lower or higher than 56 years old.

$$P(f) = 1 - e^{-e^{3.5978*\ln(force)+0.046437*(56-age)-1.1978*\left[{Pin-fixed=1 \atop Ball-socket=0}\right]-0.5866\left[{Male=1 \atop Female=0}\right]-27.778}}$$

When $age \leq Age_{peak}$

$$P(f) = 1 - e^{-e^{3.5978*\ln(force)+0.07159*(age-56)-1.1978*\left[{Pin-fixed=1 \atop Ball-socket=0}\right]-0.5866\left[{Male=1 \atop Female=0}\right]-27.778}}$$

When $age \geq Age_{peak}$

---------------- (3)

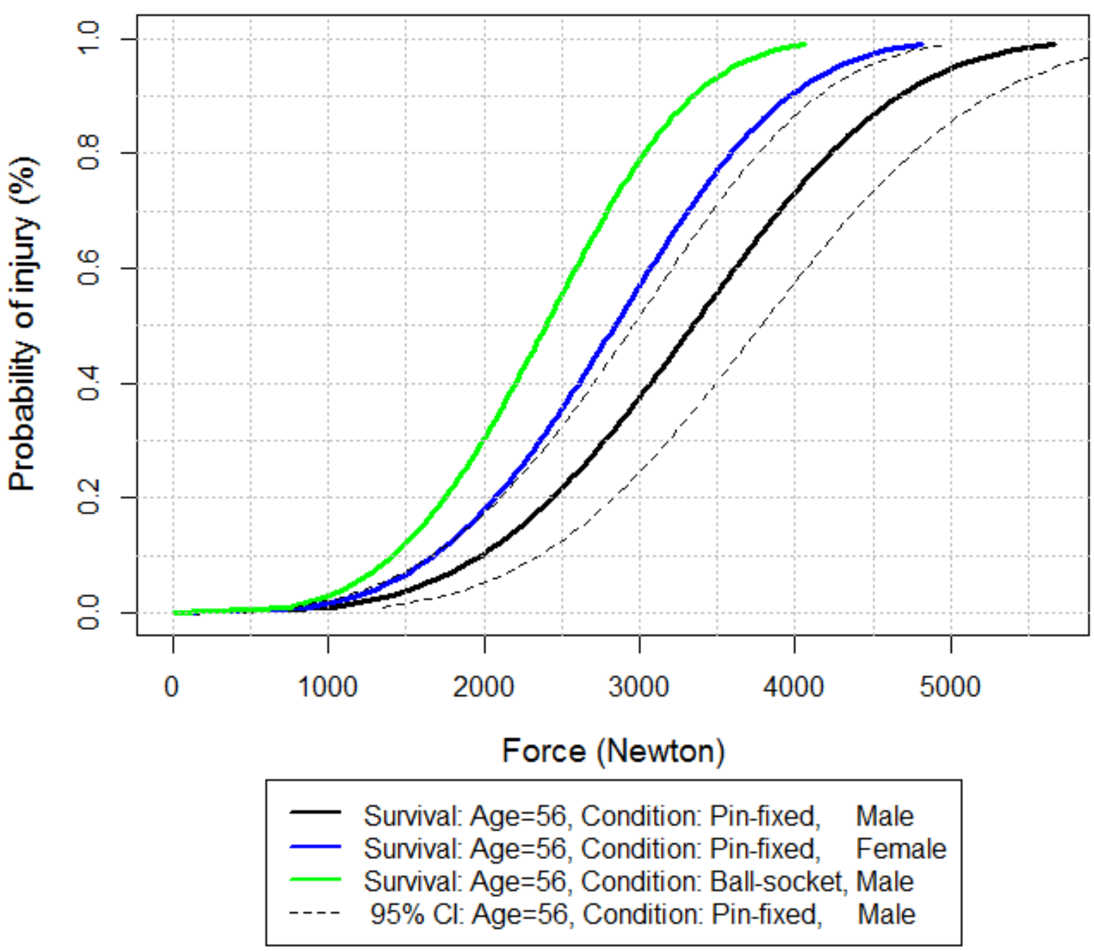

Figure 6. Injury risk functions for the clavicle at age 56 years of different gender and boundary conditions (pin-fixed and ball-socket).

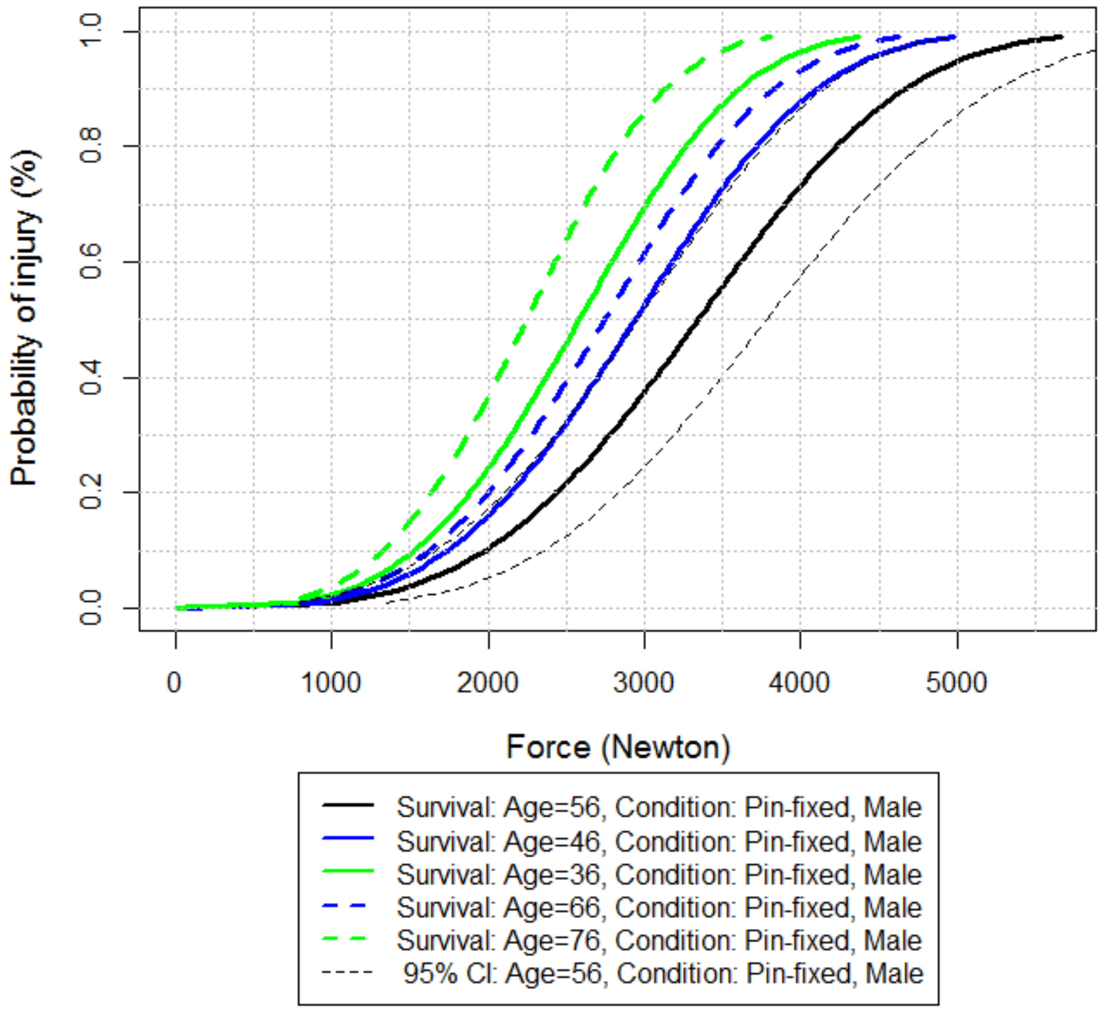

Figure 7. Injury risk functions of male clavicle under pin-fixed loading condition at different ages (36, 46, 56, 66, 76 years old)

DISCUSSION

Although the clavicle was under axial loading in these tests, due to the S shape of the clavicle, the loading mode sustained in the cross-section is actually a combined axial and bending loading condition as shown in our experiment results (Figure 3). For a simple straight beam, the failure force is proportional to the cross-sectional area. For a simple beam under three-point bending, the failure force (or failure moment) is proportional to cross-section area moment of inertia. Our correlation analysis indicates that low correlation exists between the clavicle length and cross-sectional properties at the maximum posterior concavity. Therefore, the clavicle length is not appropriate for the clavicle biomechanical response scaling. However, considering the clavicle as a non-prismatic beam, further analysis indicates that correlation of the cross-sectional properties between the anterior maximum concavity and posterior maximum concavity of the clavicle is also very low. The correlation analysis indicates that the geometric similarity assumption, which is typically assumed when developing injury risk functions, is invalid for the clavicle; therefore the clavicle fracture data was not scaled in this study. These results also indicate that geometric similarity assumption should be verified before scaling the force-deflection response of biological tissue.

The boundary condition has significant effects on the clavicle injury risk. The clavicle could sustain higher axial loading force under the pin-fixed boundary condition than under the ball-socket boundary condition. Finite element analysis was performed to study the effect of boundary condition on clavicle fracture force and to verify the results from the multivariate-survival analysis. The clavicle finite element model developed by Li et al. 2012 was used to obtain the fracture force for the pin-fixed loading condition. In addition, this model was modified and introduced the ball-socket boundary condition as used by Duprey et al. (2008). It was shown that the ball-socket boundary condition allow more degree of freedom in both end of the clavicle during the tests, which resulted in a higher bending moment, and therefore lower tolerance force.

The survival analysis in this study suggested that age affects the clavicle injury risk in a bi-modal way: the injury risk decreases as age increases to around 56 years old, and then the injury risk increases as the age continue to increase. The mechanism of age on the change of injury tolerance has been studied extensively by researchers. Recently, Forman et al. (2012) showed through a component analysis that the increase in strength through skeletal development at the young age was attributable to geometric changes, while the decrease in fracture moment in advanced age was likely due to decreases in cortical thickness combined with other factors, possibly including a decrease in cortical bone ultimate stress. However, considering that the youngest age of the specimen in our study is 14, we do not recommend apply our injury risk function to predict injury risk of subject below age 14, as significant developmental changes may happen between new born to 14 years old, extrapolating the current results into that region could be problematic.

The survival analysis shows that gender affects the clavicle injury risk prediction. A plot of the clavicle failure force VS gender in the current database also indicates that male specimens have a larger failure force than female specimens. Andermahr et al. (2007) also did a comprehensive study on the geometric properties of the 196 clavicles, where the author found that the male clavicle have larger size than that of female`s in terms of both the length and cross-section area. Kerrigan et al. (2004) has developed injury risk criteria for the tibia and femur under three point bending loading. Gender was not considered as an injury predictor in their analysis; because Mather et al. (1968) showed that the differences between male and female in the femoral was due entirely to the smaller dimensions of females, rather than to a difference in the material strength of the bone tissue. However, the clavicle force-deflection response data in our study was not scaled geometrically; this variation of size that is correlated with gender makes gender as a significant predictor in our clavicle injury function.

In the multivariate survival analysis, strain rate was not found to be a significant risk factor for clavicle injury. The effect of strain rate on the failure behavior of bone is inconsistent in the literature, with some authors reporting an increase in strength, others reporting a decrease in strength, and some researchers also find a critical strain rate with respect to ultimate failure strain (Hansen et al. 2008). The clavicle experiments performed by Arregui-Dalmases et al. (2010, 2013) include matched left and right side clavicles under quasi-static (0.63mm/s) and dynamic (1000mm/s) loading rates. A significant rate effects was observed in these experiment (Table 4). However, the clavicle failure data in the current study does not show rate effects, when compared with the study by Zhang et al. 2012, although the loading rate in the current study is a magnitude higher, and the age is also comparable between these two studies. These differences could be due to the inherent variability within the biological tissues.

Table 4. comparison of the clavicle failure force under quasi-static and dynamic loading.

Study	Boundary Condition	Subject	Age	Gender	Aspect	Loading rate(mm/s)	Fracture force(N)
Arregui-Dalmases et al. 2010; Arregui-Dalmases et al. 2013	Pin-fixed Loading condition	ECIP05	55	M	L	0.63	2235
					R	**1000**	**2967**
		ECIP06	56	M	L	0.63	3310
					R	**1000**	**3841**
		ECIP07	56	M	L	0.63	2167
					R	**1000**	**5011**
		ECIP09	37	M	R	0.63	1672
					L	**1000**	**2578**
		ECIP10	14	F	L	0.63	1207
					R	**1000**	**1959**
		ECIP11	43	F	R	0.63	2359
					L	**1000**	**2716**
		ECIP12	46	M	R	0.63	2178
					L	**1000**	**2980**
		ECIP13	46	F	L	0.63	1570
					R	**1000**	**2645**
		ECIP14	42	M	R	0.63	1878
					L	**1000**	**2453**
		ECIP15	56	M	R	0.63	3665
					L	**1000**	**4199**

In addition, the clavicle aspect (left VS right) was also not included in the final injury risk function. Student T test indicate that there is no statistical significant difference in failure force between the left and right side clavicle. In addition, Andermahr et al. (2007) also found in their study of a much larger sample size (196 clavicle specimens), that there is no statistical significant difference of the size between the left side and right side clavicle.

CONCLUSIONS

In summary, four clavicle dynamical axial loading tests were presented in this study to expand the available clavicle injury tolerance data. A database of clavicle injury tolerance under axial loading was compiled. And the clavicle axial loading injury risk function was developed with gender, boundary condition and age as covariates. The effect of age on clavicle injury risk shows a bi-phase trend, as the injury risk decreases as the age increase until 56 years old, and then the clavicle injury risk increases as age increase. The male subject has a lower clavicle injury risk compared to female subject under the same loading condition. The clavicle had a lower injury risk under the pin-fixed boundary condition than the ball-socket boundary condition (although in a real crash, the loading condition sustained by the clavicle might be a combination of both). The injury criteria established in this study could be a useful tool for clavicle injury risk prediction and help design countermeasures for injury prevention.

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APPENDIX

Table 5. clavicle axial loading database(Injury Status: 1 fractured, 0 non-fractured; boundary condition, 1 ball socket joint, 2 pin-fixed)

Study	Sample Number	Boundary Condition	Subject	Age	Gender	Aspect	Loading rate(mm/s)	Fracture force(N)	Injury Status
Harnroongroj et al. 2000	1	1	1	25	M	R	0.16	2023	1
	2	1	2	21	M	L	0.16	2815	1
	3	1	3	24	M	R	0.16	1301	1
	4	1	4	19	M	L	0.16	1403	1
	5	1	5	21	M	R	0.16	1599	1
	6	1	6	24	M	L	0.16	1356	1
	7	1	7	24	M	R	0.16	627	1
	8	1	8	25	M	L	0.16	1999	1
	9	1	9	23	M	R	0.16	949	1
	10	1	10	18	M	L	0.16	949	1
	11	1	11	24	M	R	0.16	1560	1
	12	1	12	25	M	L	0.16	1733	1
Duprey et al. 2008	13	1	HMS01	85	F	R	1000	963	1
	14	1	HMS01	85	F	L	1000	1034	1
	15	1	JNDS01	86	M	L	1500	1628	1
	16	1	JNDS01	86	M	R	1500	1594	1
	17	1	HMS11	84	F	L	1500	1379	1
	18	1	HMS11	84	F	R	1500	1218	1
	19	1	H0406	86	F	R	1000	834	1
	20	1	H0406	86	F	L	1000	660	1
	21	1	H205	54	F	L	2000	2077	1
	22	1	H205	54	F	R	2500	2324	1
	23	1	H15	83	M	L	2000	2065	1
	24	1	H15	83	M	R	2000	1938	1
	25	1	GG1	82	M	R	1500	1421	1
	26	1	GG1	82	M	L	1500	1346	1
	27	1	H29	84	M	R	1500	1369	1
	28	1	H29	84	M	L	1500	1482	1
	29	1	H36	62	M	L	1500	1304	1
	30	1	H36	62	M	R	2000	1974	1

Arregui-Dalmases et al. 2010	31	2	ECIP01	47	M	R	0.63	2478	1
	32	2	ECIP03	49	M	L	0.63	2692	1
	33	2	ECIP04	54	M	L	0.63	3324	1
	34	2	ECIP05	55	M	L	0.63	2235	1
	35	2	ECIP06	56	M	L	0.63	3310	1
	36	2	ECIP07	56	M	L	0.63	2167	1
	37	2	ECIP08	23	M	R	0.63	2966	1
	38	2	ECIP09	37	M	R	0.63	1672	1
	39	2	ECIP10	14	F	L	0.63	1207	1
	40	2	ECIP11	43	F	R	0.63	2359	1
	41	2	ECIP12	46	M	R	0.63	2178	1
	42	2	ECIP13	46	F	L	0.63	1570	1
	43	2	ECIP14	42	M	R	0.63	1878	1
	44	2	ECIP15	56	M	R	0.63	3665	1
Zhang et al. 2013	45	2	217	64	M	L	100	3137.78	1
	46	2	218	63	M	L	100	2367.57	1
	47	2	218	63	M	R	100	2294.91	1
	48	2	363	60	M	L	100	2182.89	1
	49	2	363	60	M	R	100	2468.07	1
	50	2	364	63	F	R	100	4390.81	1
	51	2	400	53	M	L	100	N/A	0
	52	2	400	53	M	R	100	4103.78	1
	53	2	454	55	M	L	100	3238	1
	54	2	454	55	M	R	100	2781.3	1
Current study	55	2	468	67	M	R	1000	2906	1
	56	2	473	54	M	L	1000	2686	1
	57	2	473	54	M	R	1000	2934	1
	58	2	480	71	M	L	1000	2678	1
Arregui-Dalmases et al. Dynamical	59	2	ECIP05	55	M	R	1000	2967	1
	60	2	ECIP06	56	M	R	1000	3841	1
	61	2	ECIP07	56	M	R	1000	5011	1
	62	2	ECIP09	37	M	L	1000	2578	1
	63	2	ECIP10	14	F	R	1000	1959	1
	64	2	ECIP11	43	F	L	1000	2716	1
	65	2	ECIP12	46	M	L	1000	2980	1
	66	2	ECIP13	46	F	R	1000	2645	1

	67	2	ECIP14	42	M	L	1000	2453	1
	68	2	ECIP15	56	M	L	1000	4199	1