Stratasys – 3D4Med
Comparative analysis on suturable vessels

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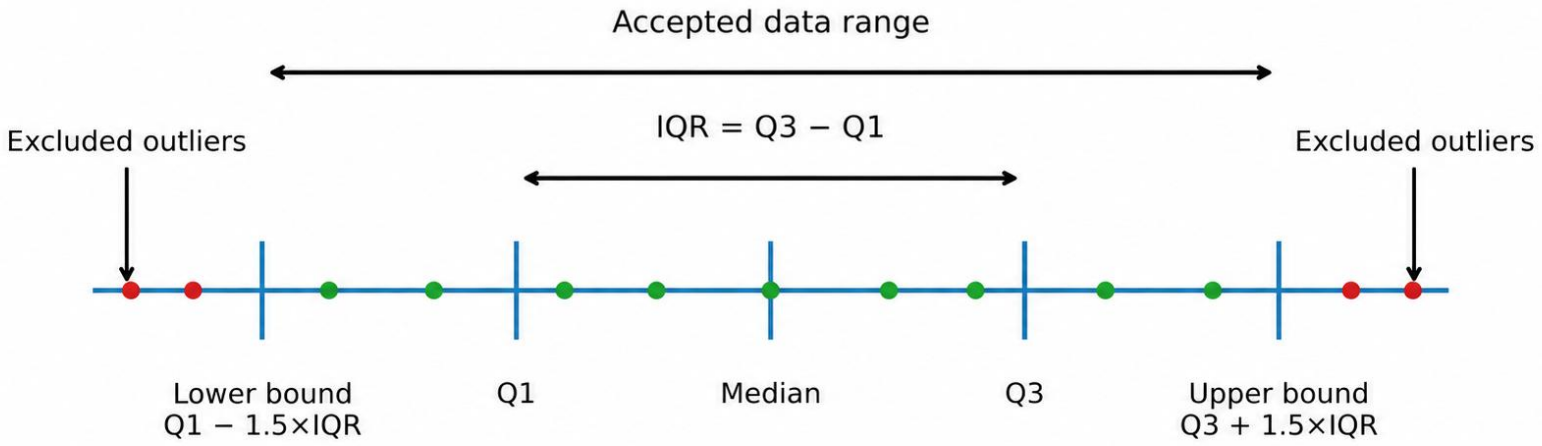
Tested Materials

			J8		J5	
N.	**Label**	**What was printed?**	**Core Composition**	**Coating Composition**	**Core Composition**	**Coating Composition**
1	SBV-1	4% ToughWhite	Agilus 65 - TM 35	0,2mm Agilus 96 – TW 4	Elastico 65 – TM 35	0,2mm Elastico 96 – TW 4
2	SBV-2	8% ToughWhite	Agilus 65 - TM 35	0,2mm Agilus 92 – TW 8	Elastico 65 – TM 35	0,2mm Elastico 92 – TW 8
3	SBV-3	15% ToughWhite	Agilus 65 - TM 35	0,2mm Agilus 85 – TW 15	Elastico 65 – TM 35	0,2mm Elastico 85 – TW 15
4	SP-12 Hi	High strength vessel - Ref	Agilus 65 - TM 35	0,2mm Agilus 85 – Clr 15	Elastico 65 – TM 35	0,2mm Elastico 85 – Clr 15
5	SP-16 Med	Medium strenght vessel - Ref	Agilus 65 - TM 35	0,2mm Agilus 92 – BM 8	Elastico 65 – TM 35	0,2mm Elastico 92 – BM 8

Interquartile Range Method

- Outliers were identified using the interquartile range method. After sorting the data in ascending order, Q1 and Q3 were calculated using Excel's QUARTILE function. The interquartile range was defined as **IQR = Q3 – Q1**. Values lower than Q1 − 1.5 × IQR or higher than Q3 + 1.5 × IQR were classified as outliers and excluded from the analysis.

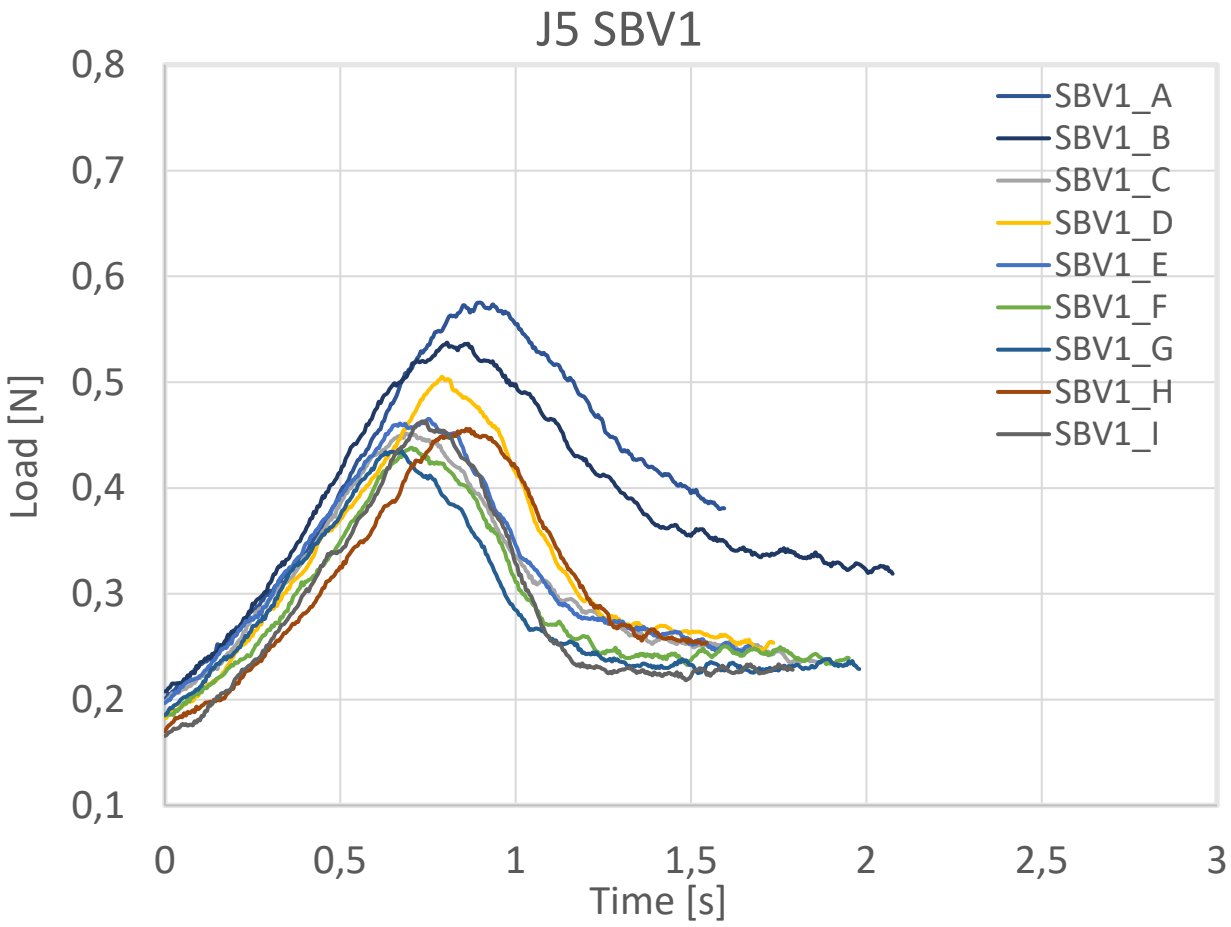
- In the following graphs only included data are reported

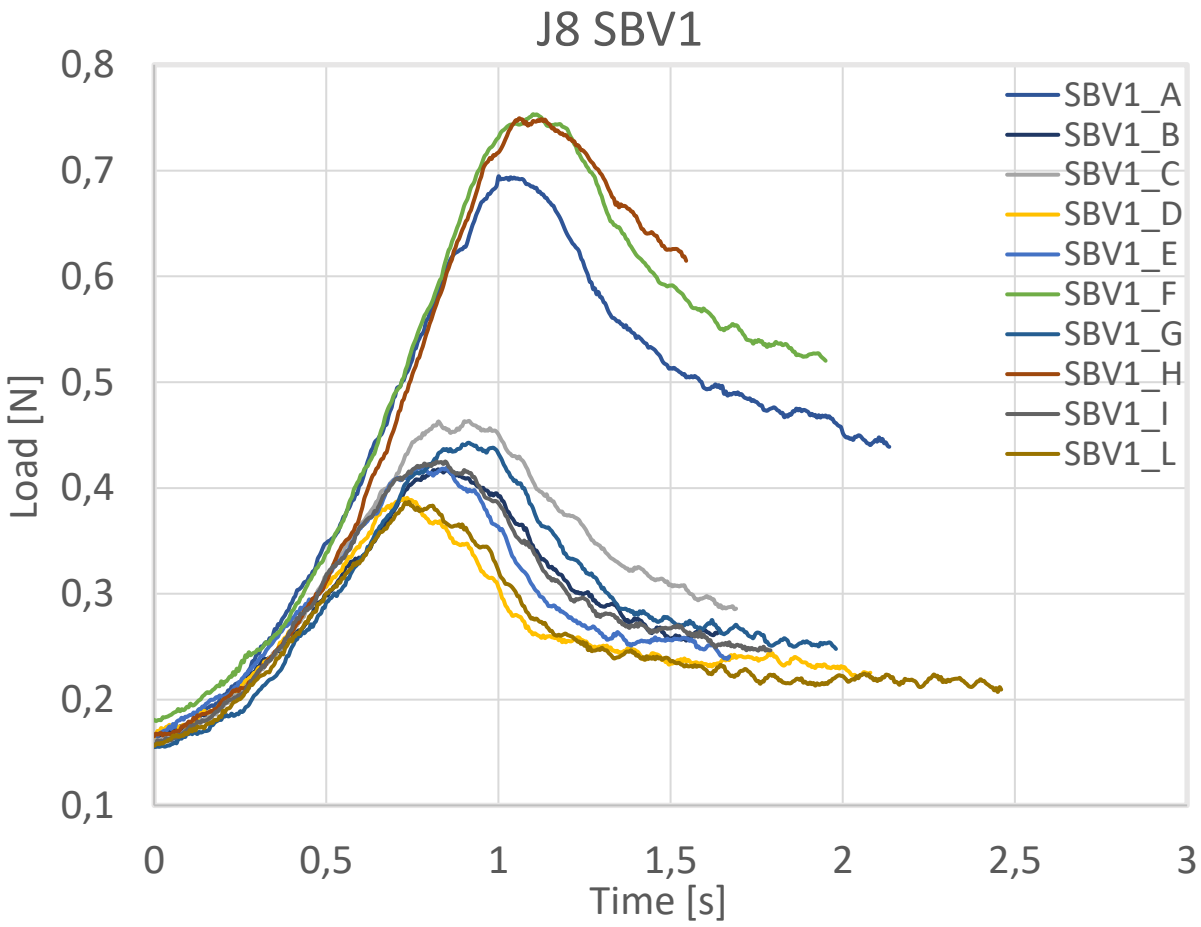


1. Sort data in ascending order
2. Calculate Q1 and Q3 using Excel QUARTILE function
3. Calculate IQR = Q3 − Q1
4. Define bounds using k = 1.5
5. Exclude values outside the bounds

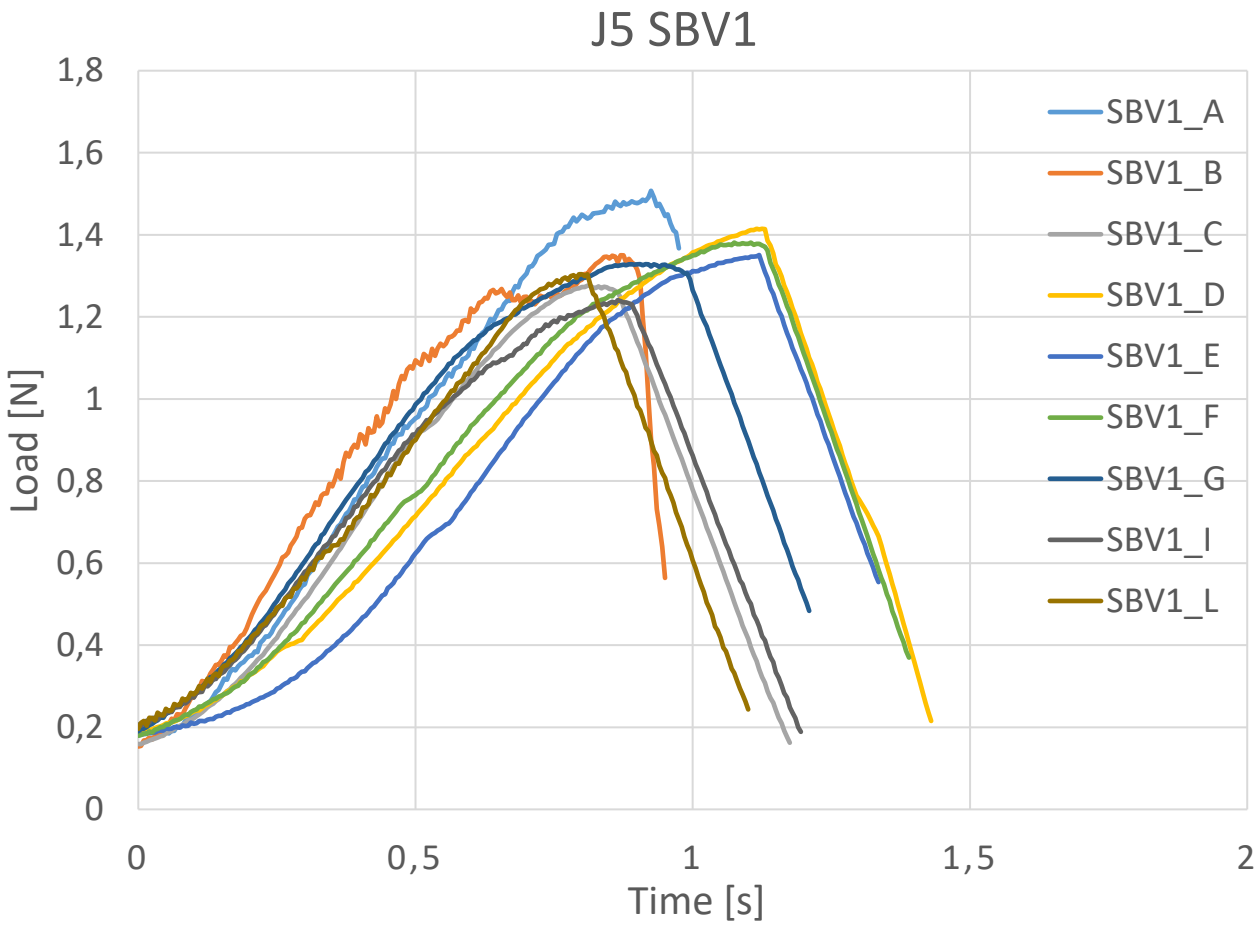
Lower bound = Q1 − k × (Q3 − Q1)
Upper bound = Q3 + k × (Q3 − Q1)
k = 1.5

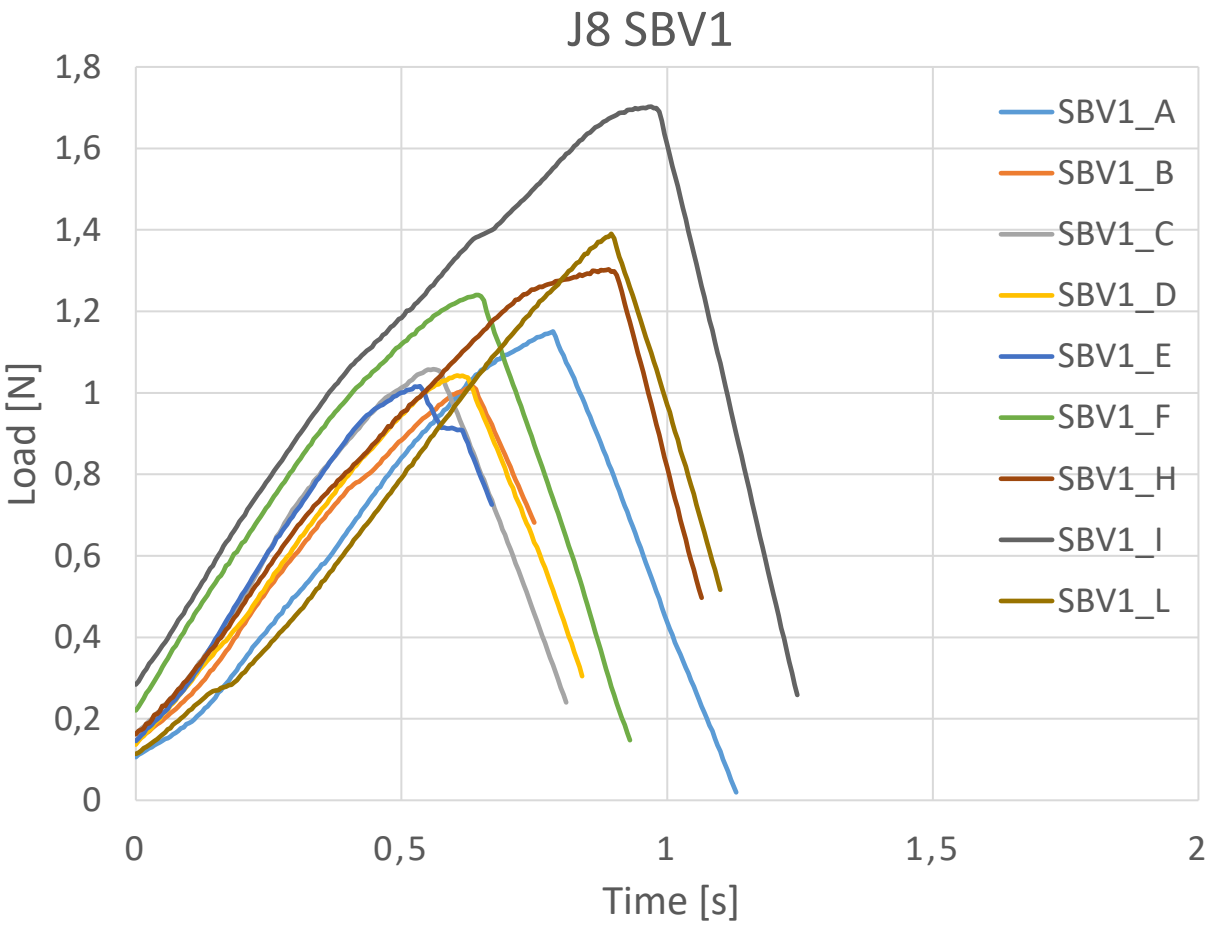
Puncture SBV1



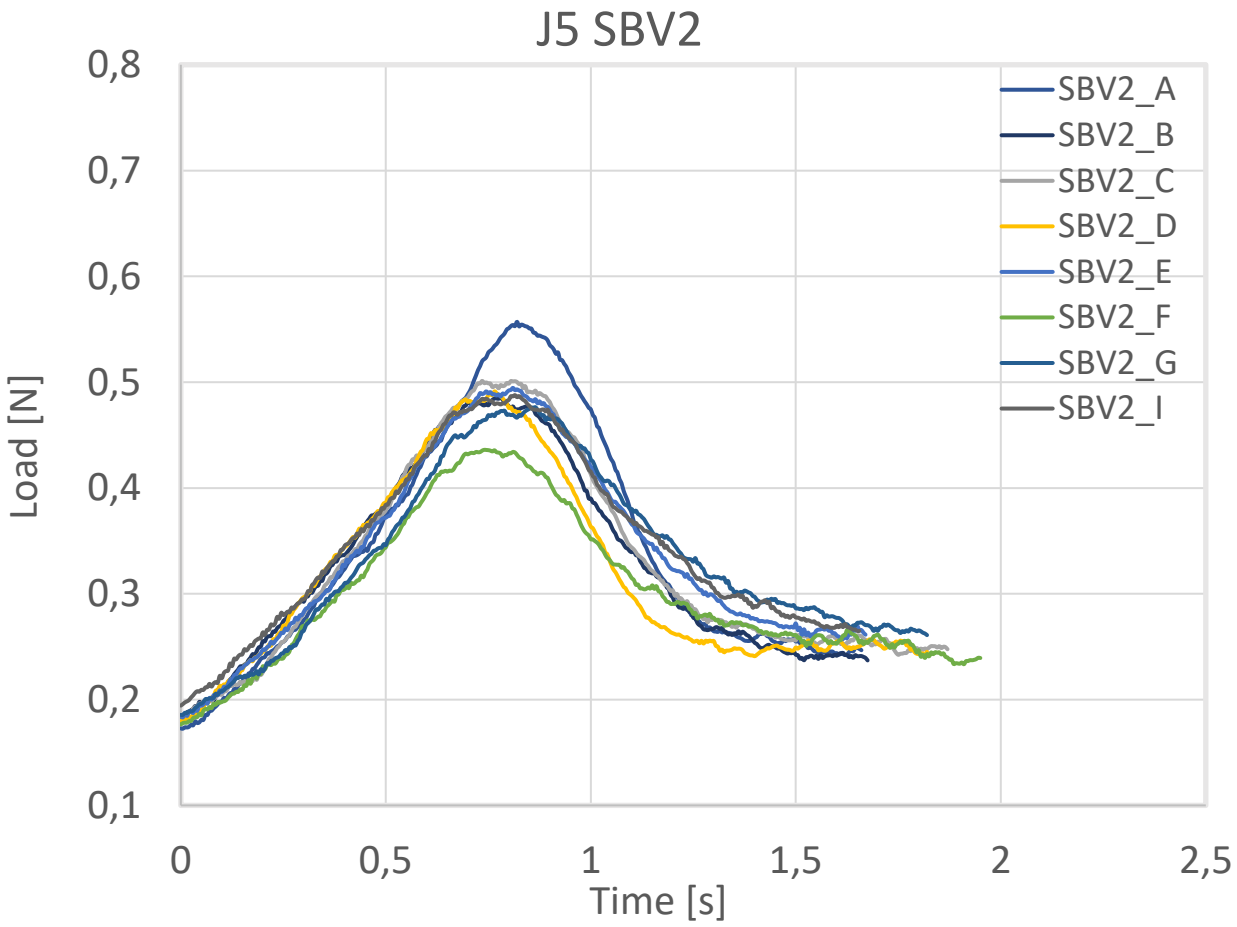


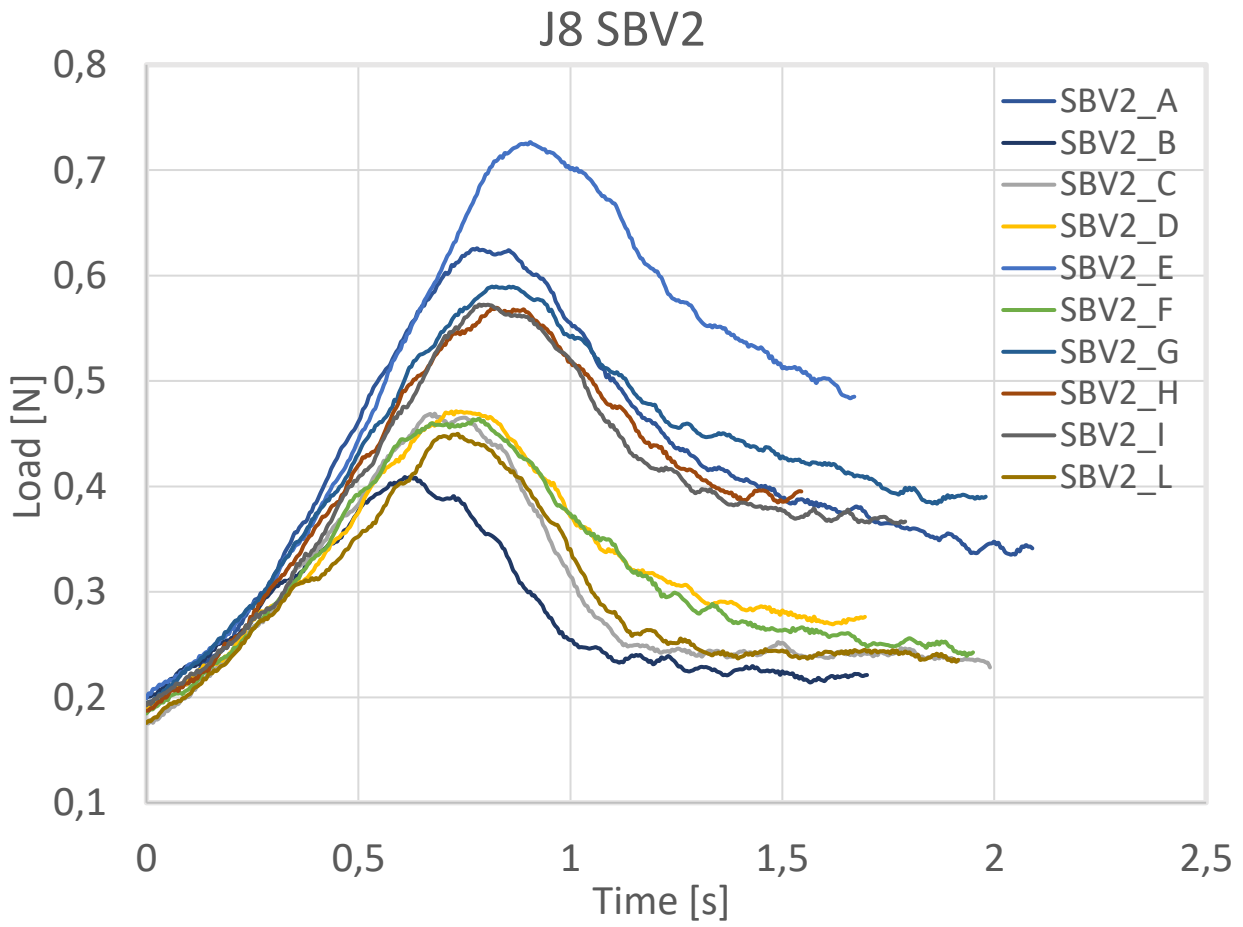
Suture SBV1


J5 SBV1
Load [N]
Time [s]
0
0,2
0,4
0,6
0,8
1
1,2
1,4
1,6
1,8
0
0,5
1
1,5
2
SBV1_A
SBV1_B
SBV1_C
SBV1_D
SBV1_E
SBV1_F
SBV1_G
SBV1_I
SBV1_L

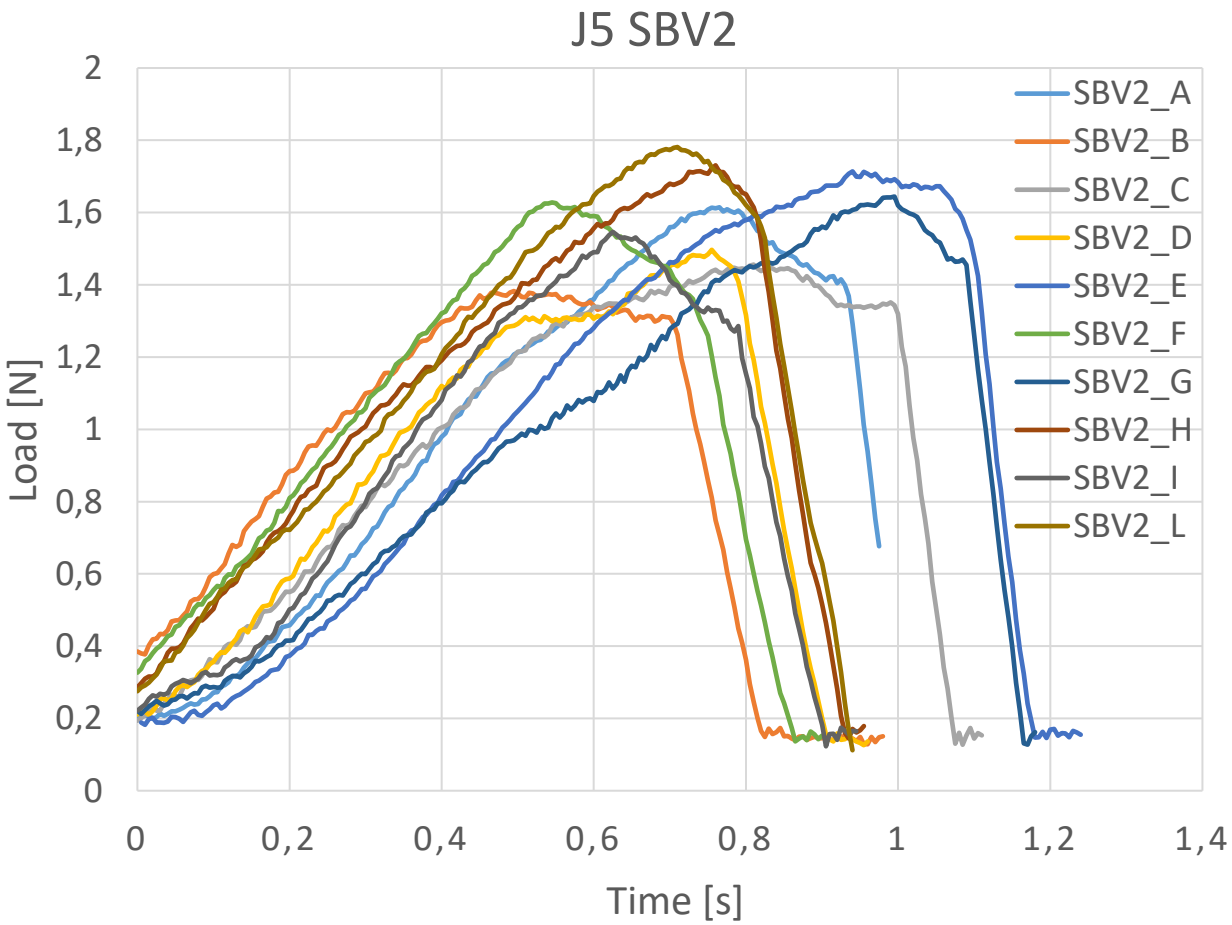

J8 SBV1
Load [N]
Time [s]
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0,2
0,4
0,6
0,8
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1,2
1,4
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1,8
0
0,5
1
1,5
2
SBV1_A
SBV1_B
SBV1_C
SBV1_D
SBV1_E
SBV1_F
SBV1_H
SBV1_I
SBV1_L

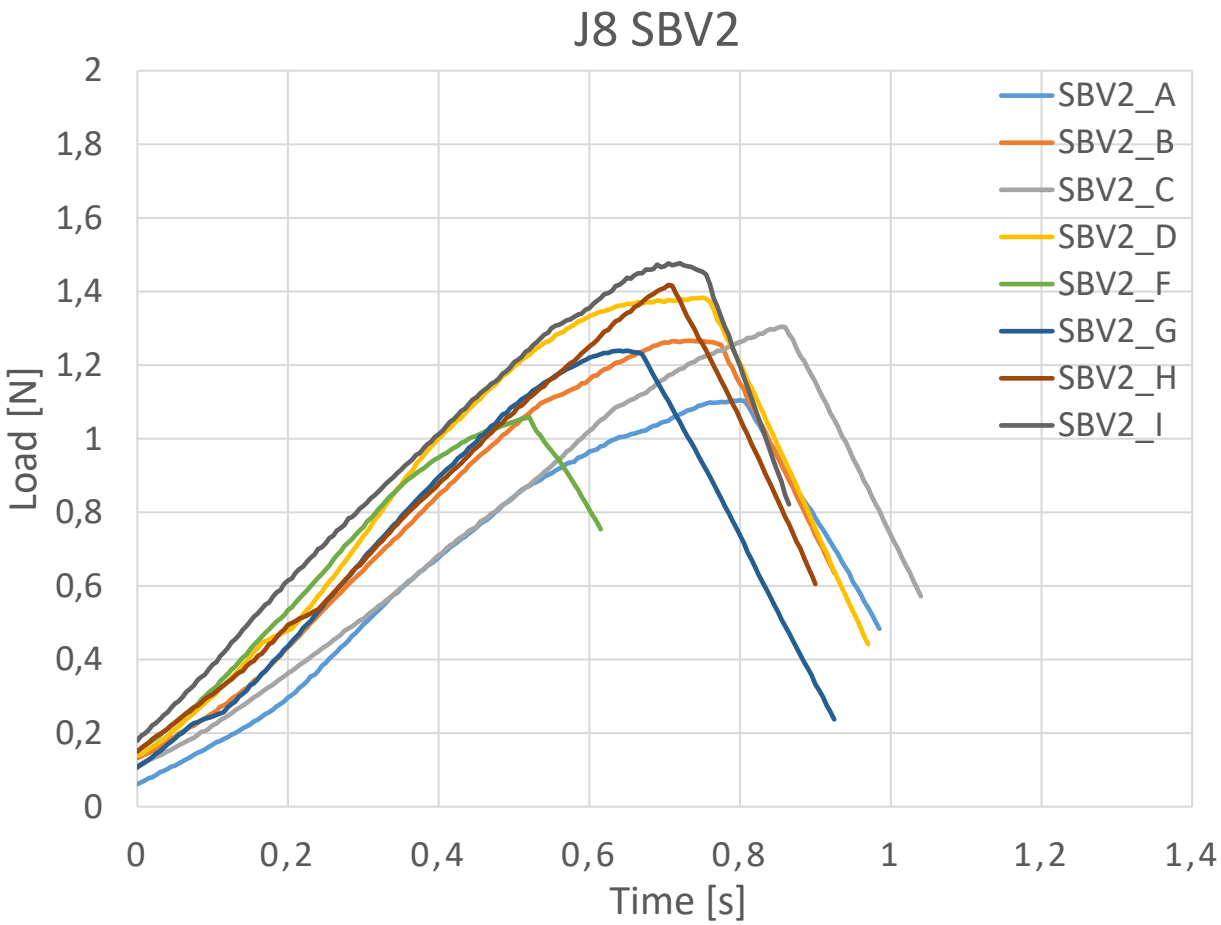
Puncture SBV2



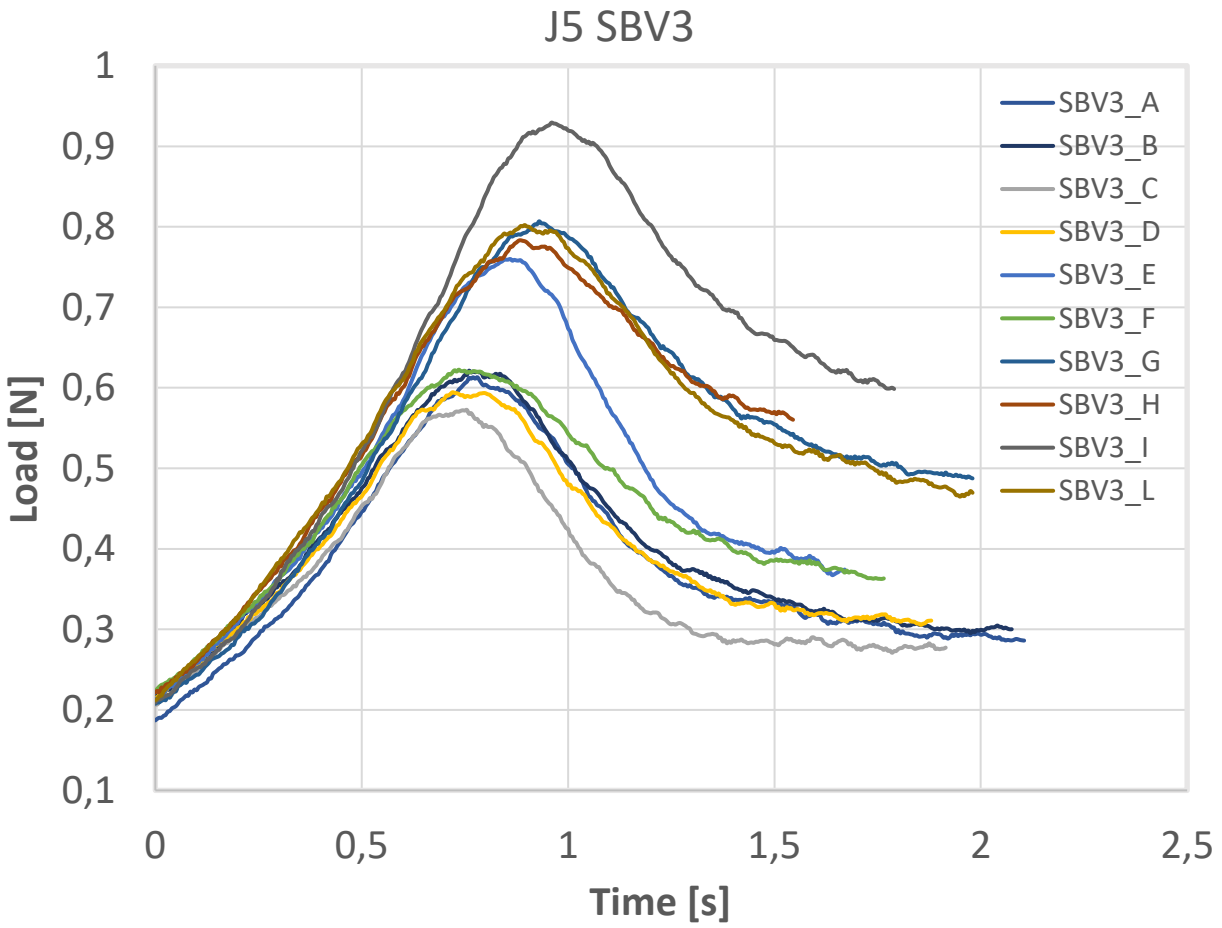


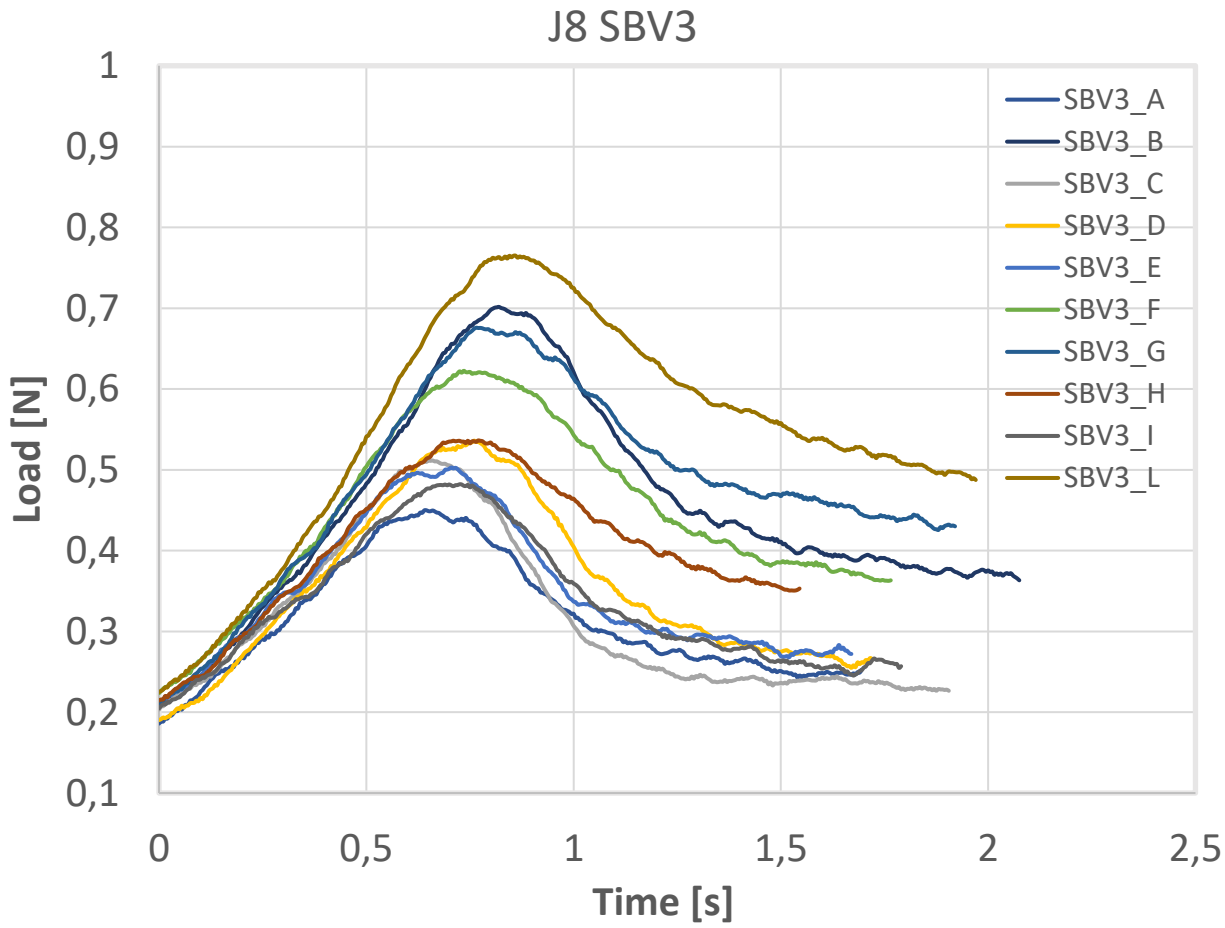
Suture SBV2


J5 SBV2
Load [N]
Time [s]
SBV2_A
SBV2_B
SBV2_C
SBV2_D
SBV2_E
SBV2_F
SBV2_G
SBV2_H
SBV2_I
SBV2_L

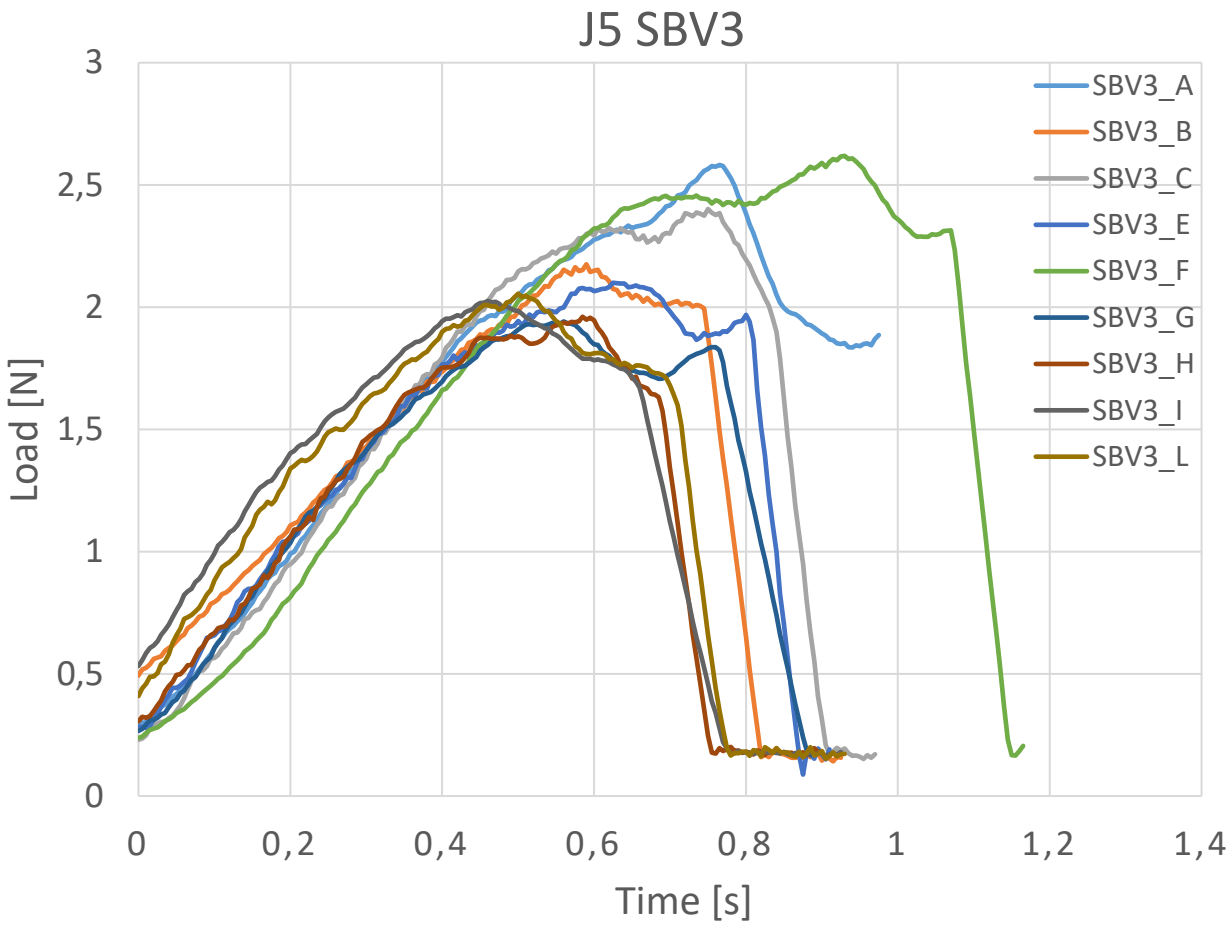

J8 SBV2
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Time [s]
SBV2_A
SBV2_B
SBV2_C
SBV2_D
SBV2_F
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SBV2_H
SBV2_I

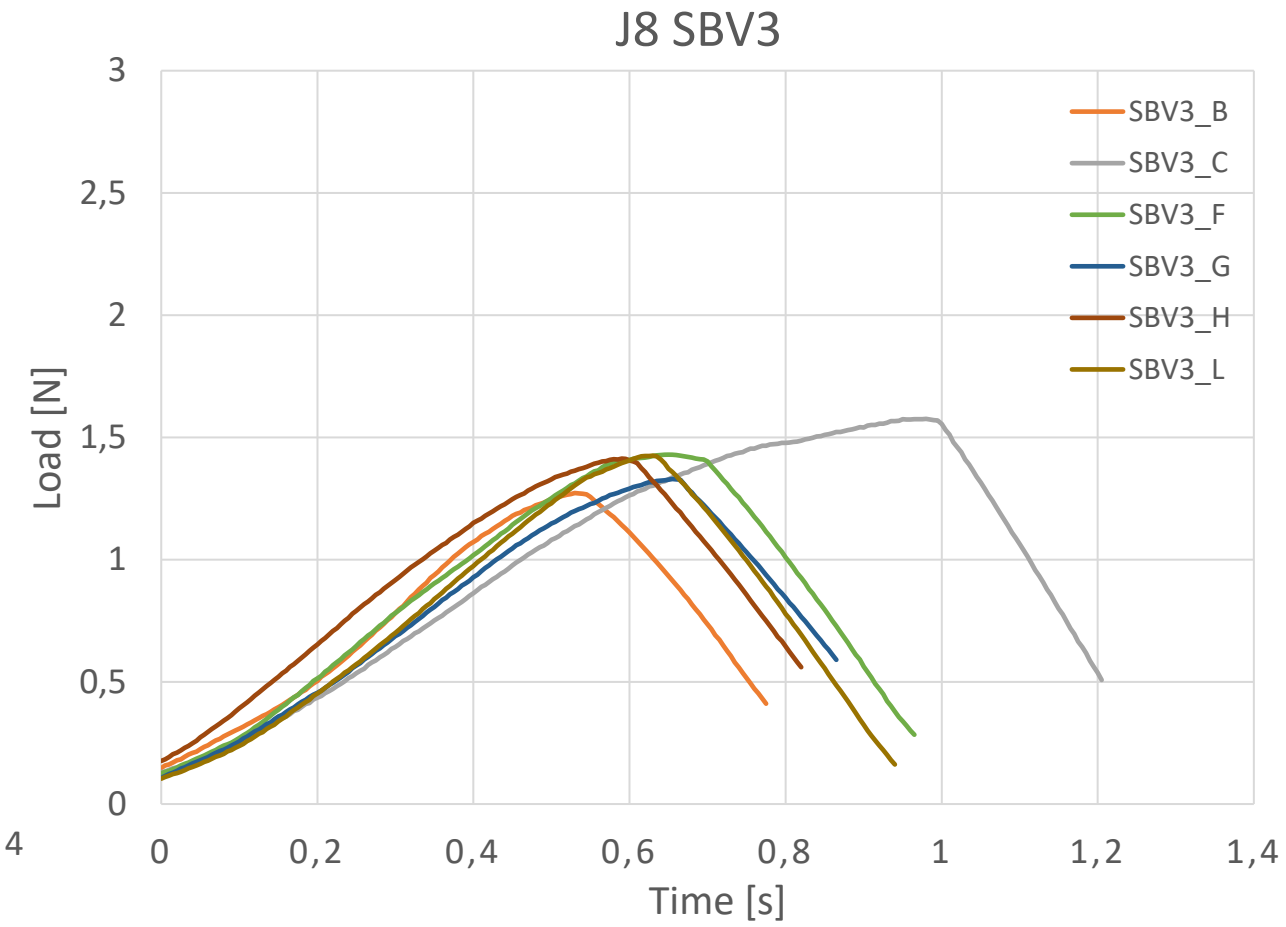
Puncture SBV3



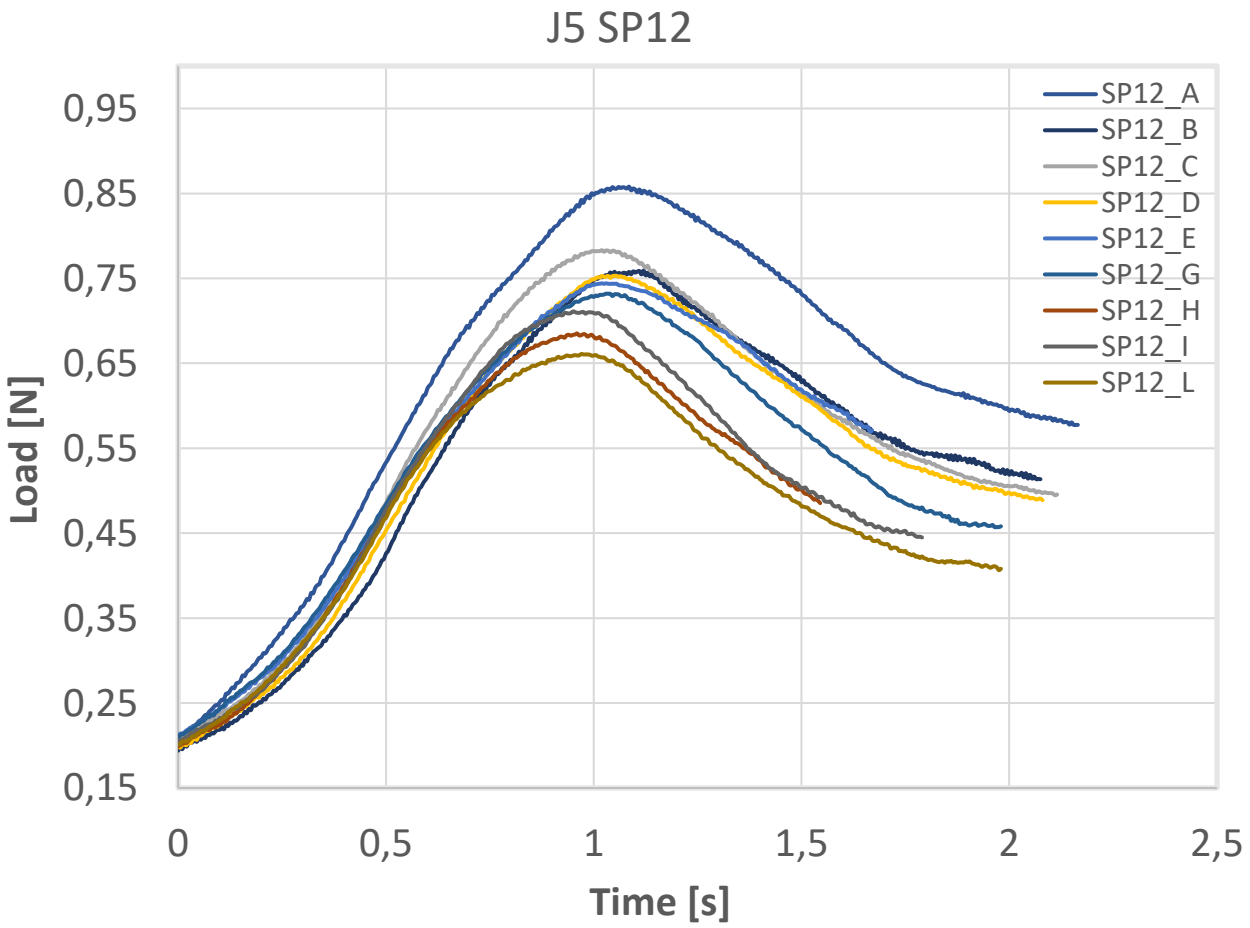


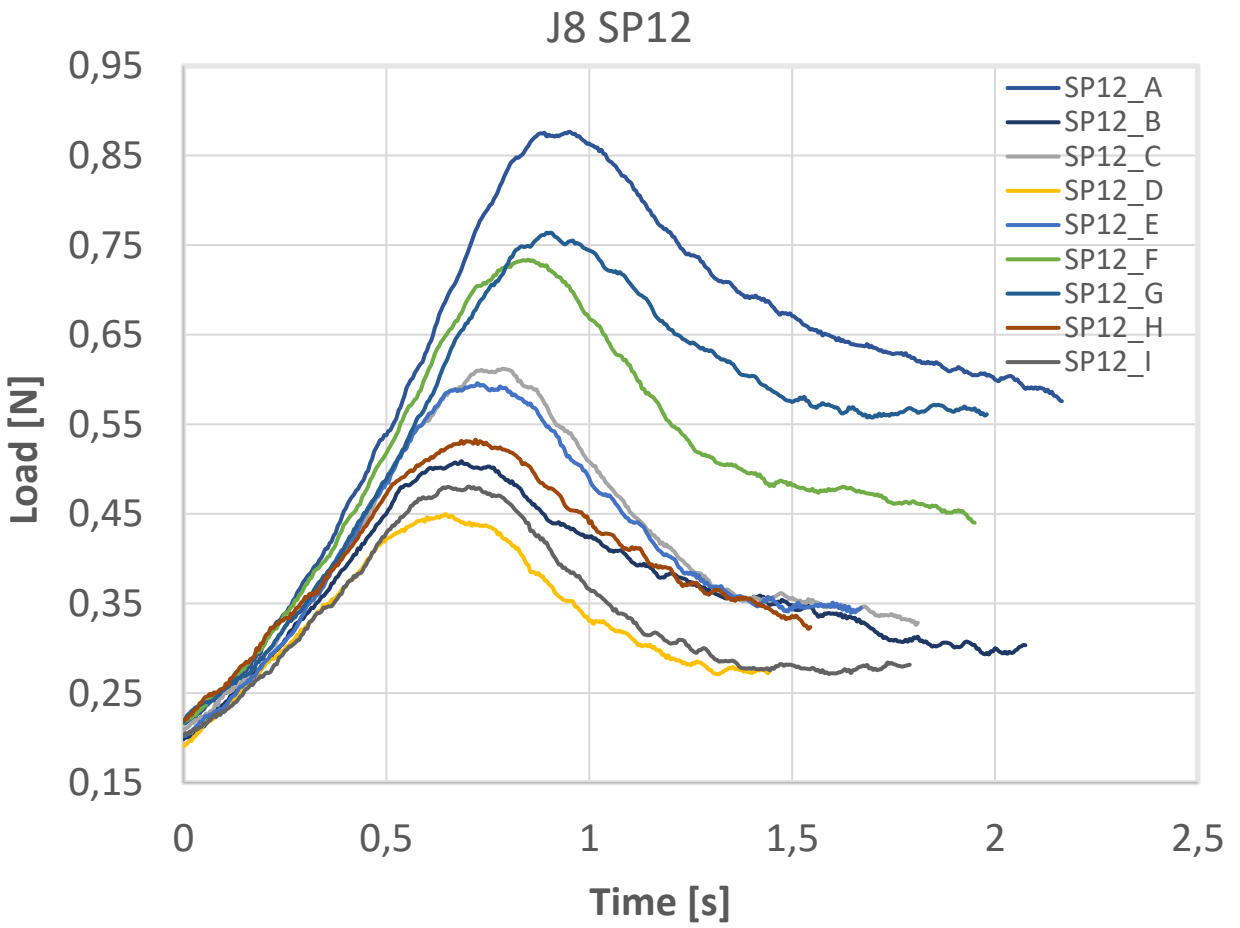
Suture SBV3


J5 SBV3
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Time [s]
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SBV3_C
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SBV3_G
SBV3_H
SBV3_I
SBV3_L

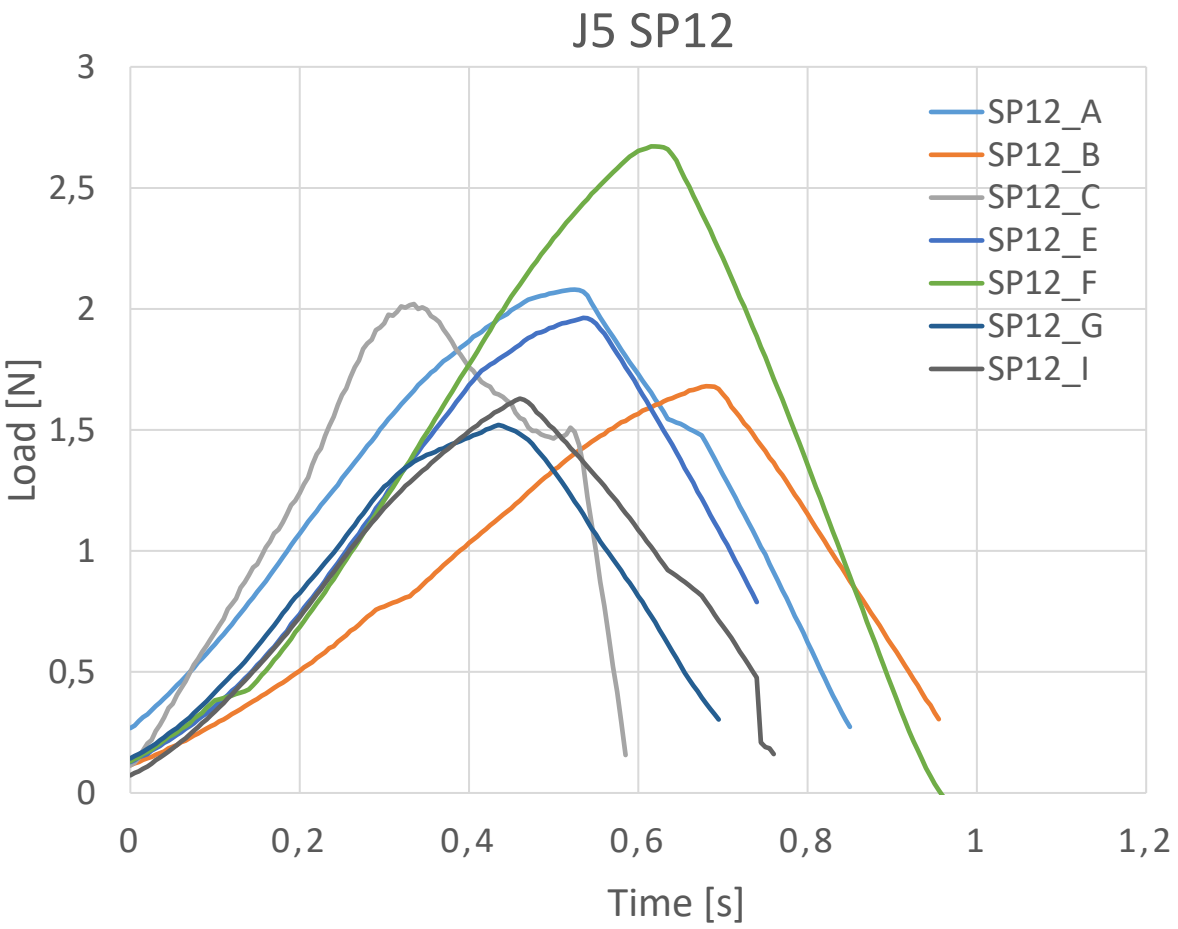

J8 SBV3
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Time [s]
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SBV3_C
SBV3_F
SBV3_G
SBV3_H
SBV3_L

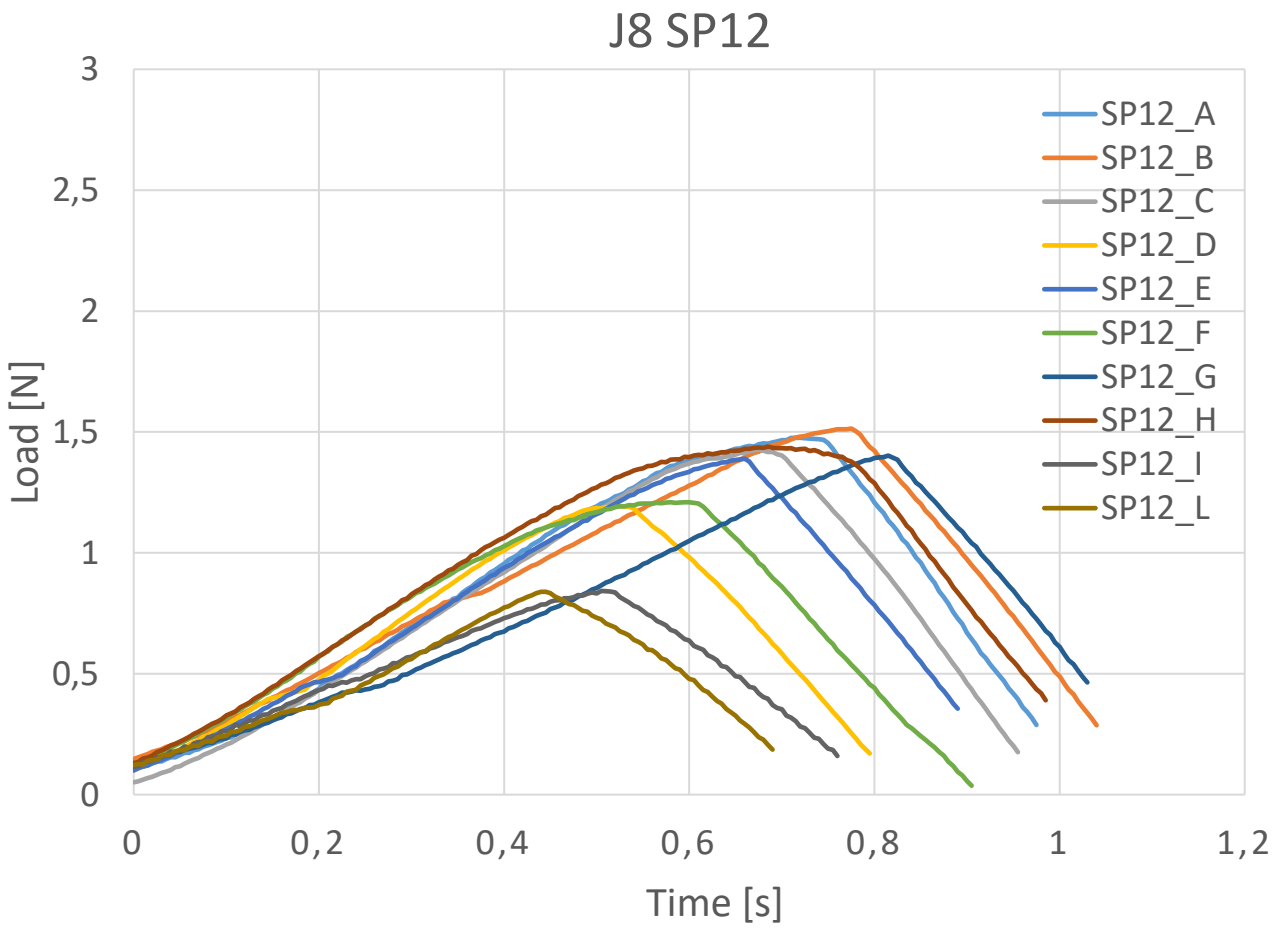
Puncture SP12



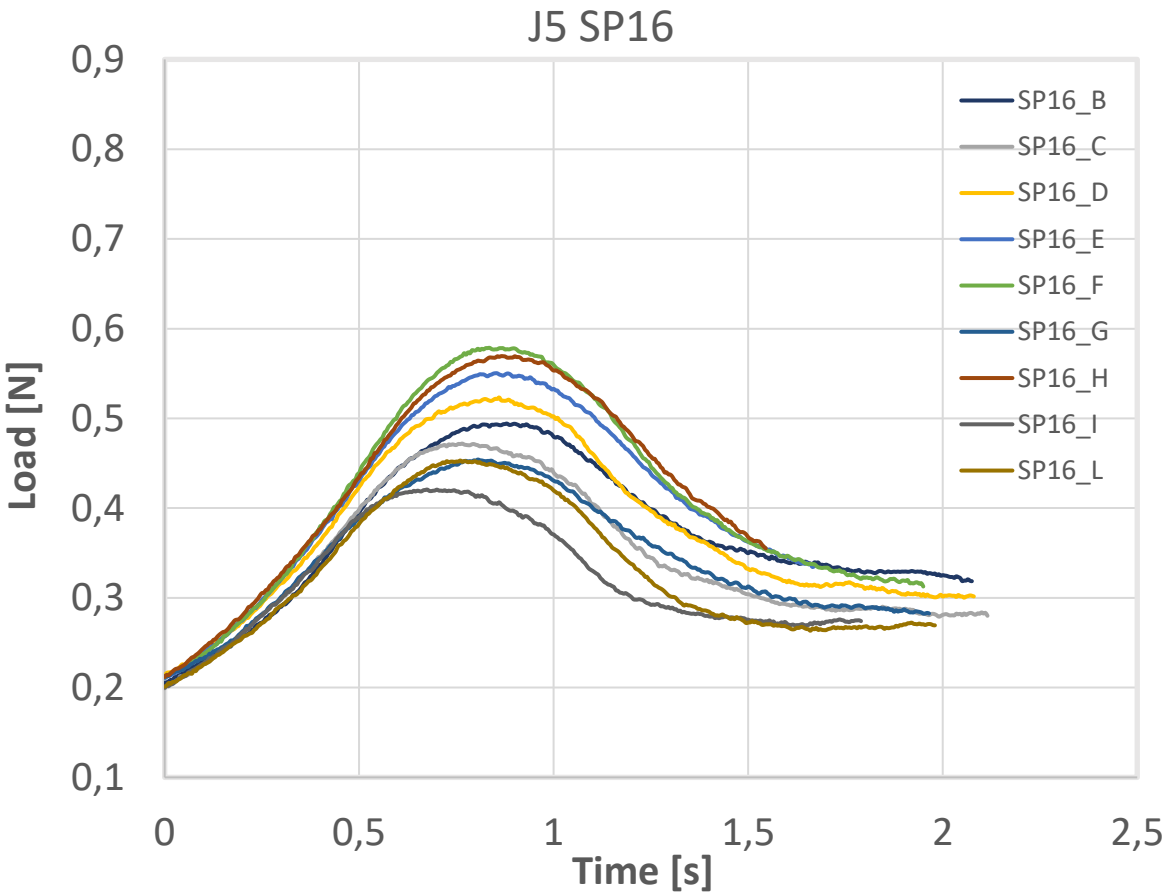


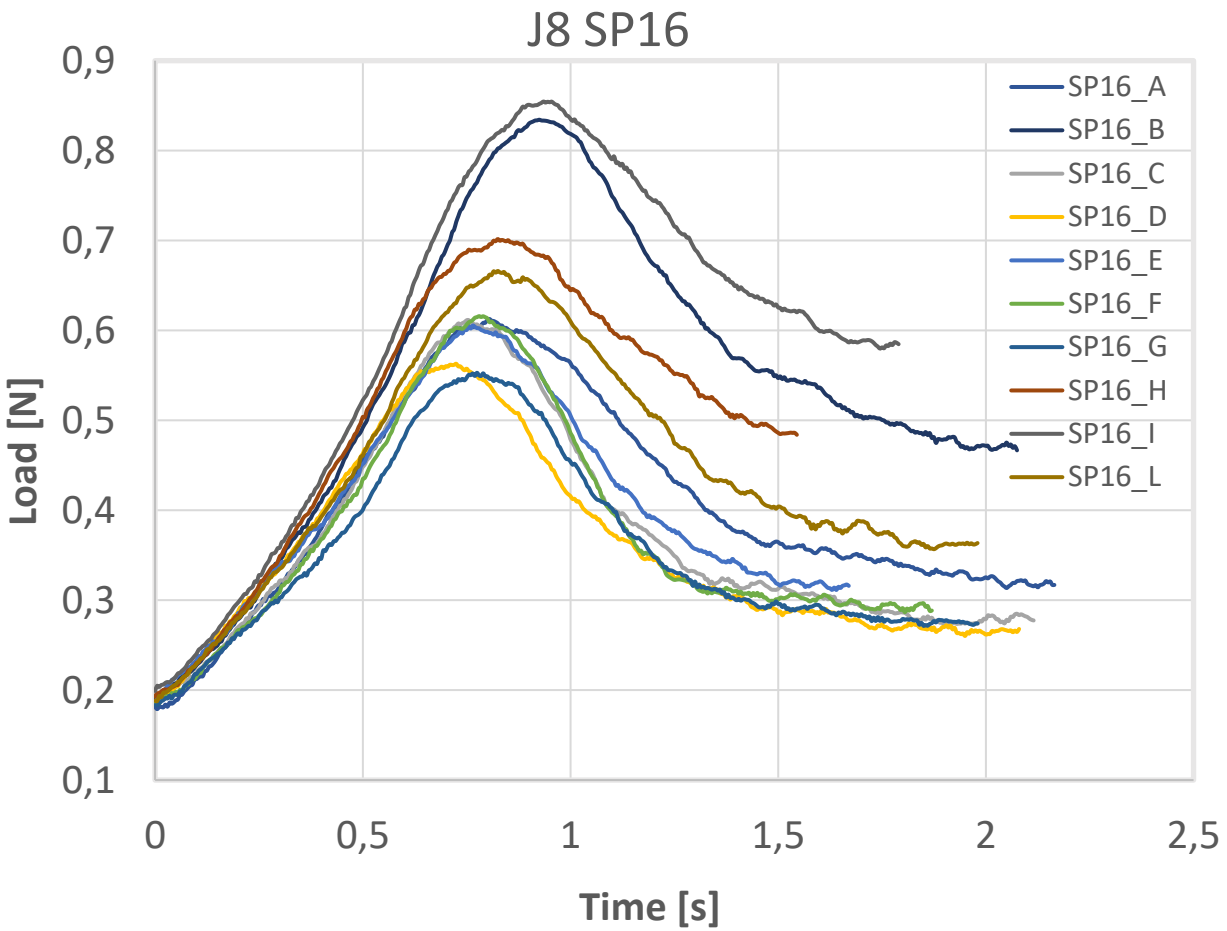
Suture SP12


J5 SP12
Load [N]
Time [s]
SP12_A
SP12_B
SP12_C
SP12_E
SP12_F
SP12_G
SP12_I
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0,4
0,6
0,8
1
1,2

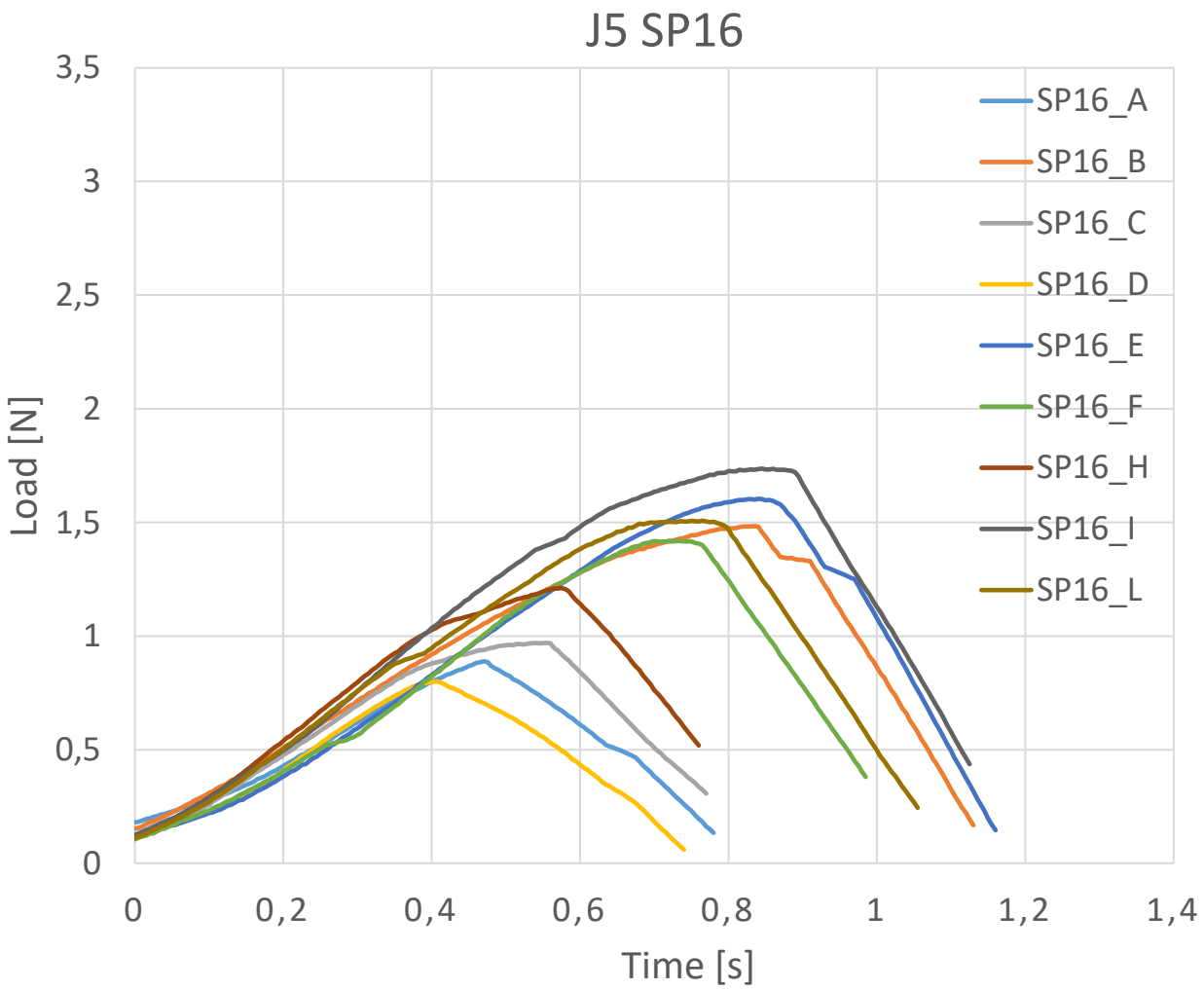

J8 SP12
Load [N]
Time [s]
SP12_A
SP12_B
SP12_C
SP12_D
SP12_E
SP12_F
SP12_G
SP12_H
SP12_I
SP12_L
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1,5
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2,5
3
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0,8
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1,2

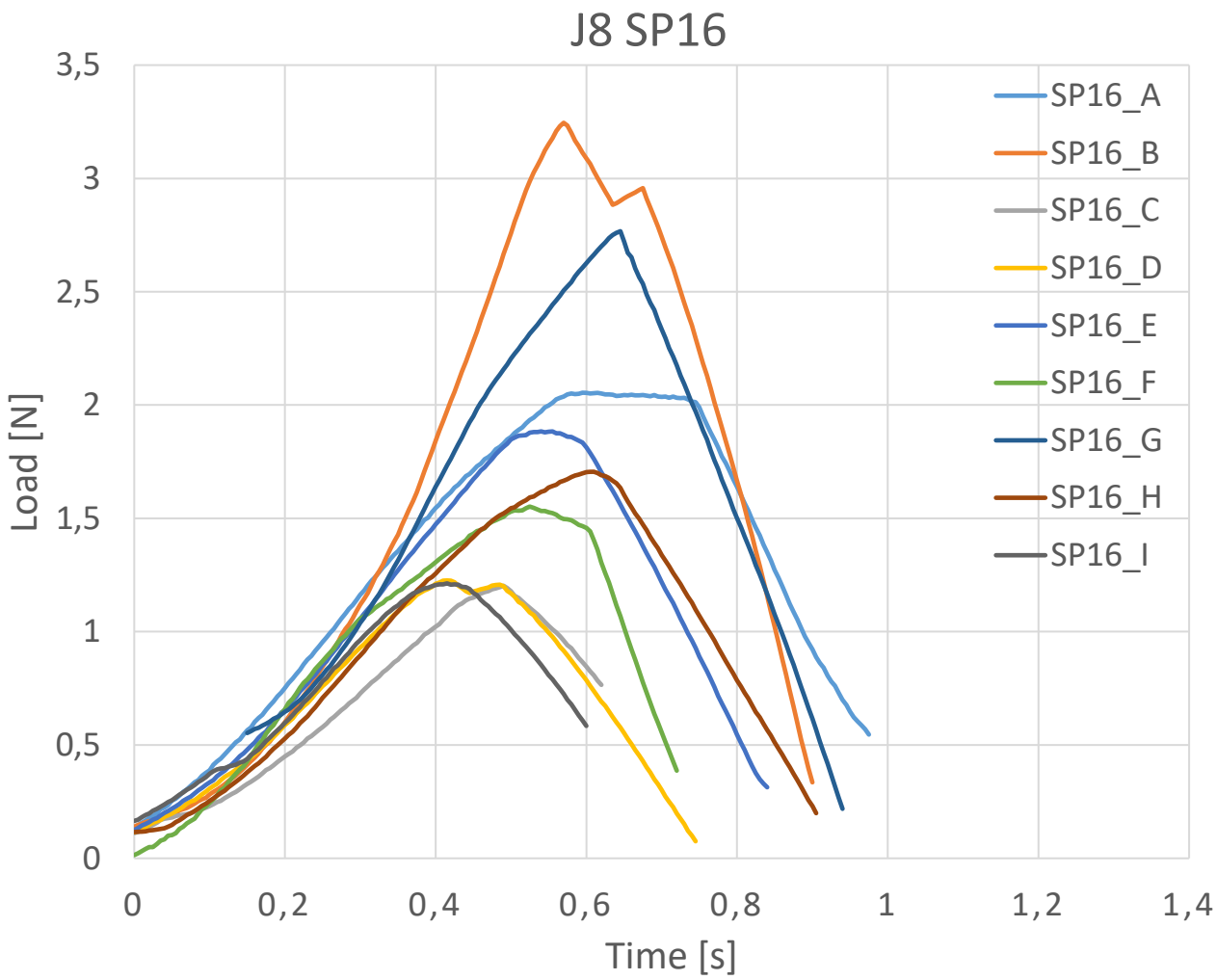
Puncture SP16





Suture SP16


J5 SP16
Load [N]
Time [s]
SP16_A
SP16_B
SP16_C
SP16_D
SP16_E
SP16_F
SP16_H
SP16_I
SP16_L

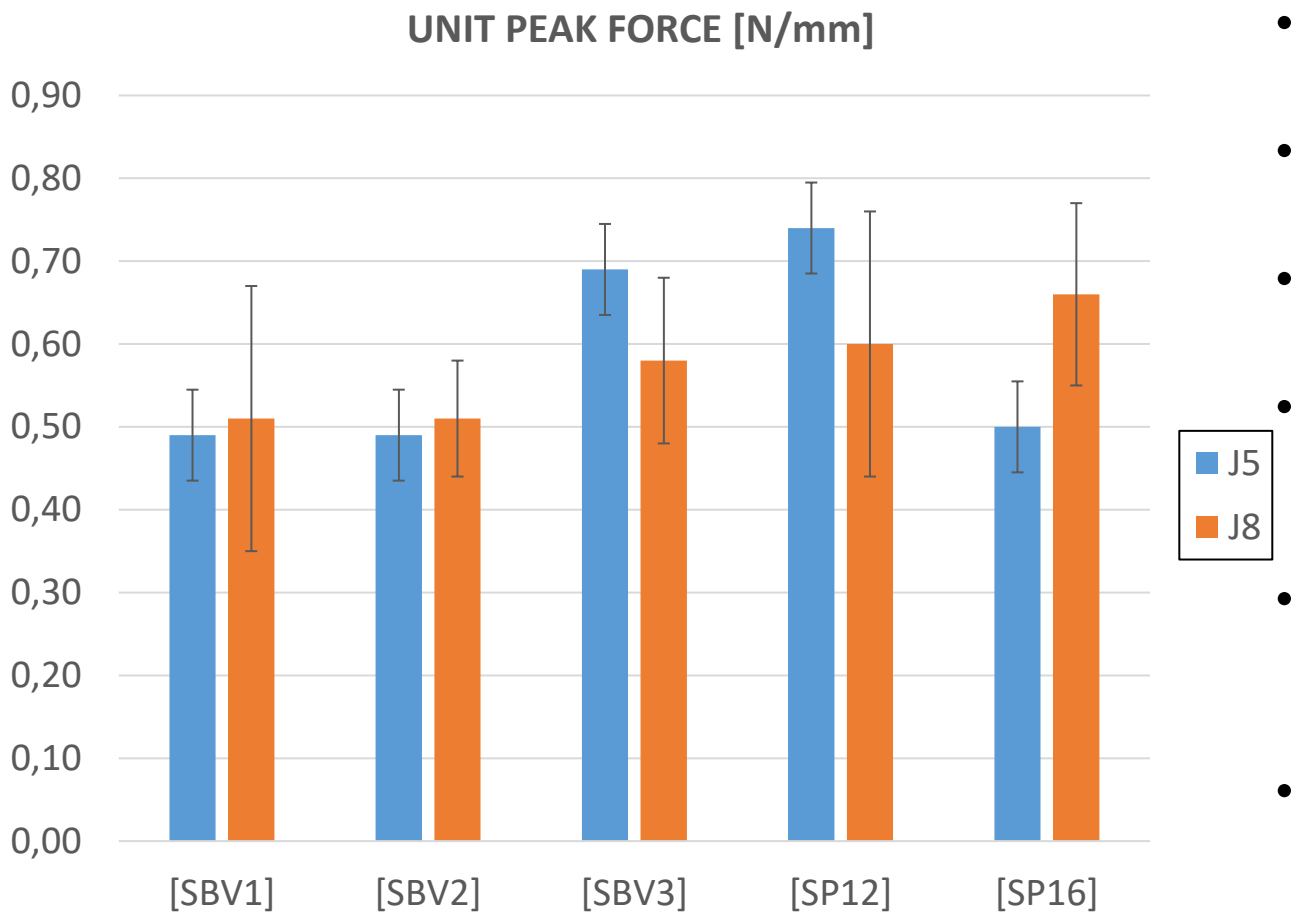

J8 SP16
Load [N]
Time [s]
SP16_A
SP16_B
SP16_C
SP16_D
SP16_E
SP16_F
SP16_G
SP16_H
SP16_I

J5 vs J8 Comparison

				J5			J8			J5 vs J8	
Type	Preset	Parameter	Unit	n	Mean	Dev. std	n	Mean	Dev. std	Δ mean J8-J5	[Δ mean J5/Δ mean J8-J5] %
Puncture	SBV1	Unit Peak Force	N/mm	9	0,49	0,05	10	0,51	0,16	0,02	4,1%
Suture Traction	SBV1	Ultimate Stress	N/mm²	9	9,65	0,56	9	8,67	1,63	-0,98	-10,2%
Suture Traction	SBV1	Max Displacement Norm	1/mm	9	2,84	0,55	9	2,22	0,59	-0,62	-21,8%
Puncture	SBV2	Unit Peak Force	N/mm	8	0,49	0,03	10	0,51	0,07	0,02	4,1%
Suture Traction	SBV2	Ultimate Stress	N/mm²	10	11,42	0,91	8	9,15	1,05	-2,27	-19,9%
Suture Traction	SBV2	Max Displacement Norm	1/mm	10	2,06	0,26	8	2,02	0,29	-0,04	-1,9%
Puncture	SBV3	Unit Peak Force	N/mm	10	0,69	0,12	10	0,58	0,10	-0,11	-15,9%
Suture Traction	SBV3	Ultimate Stress	N/mm²	9	15,76	1,87	6	10,05	0,74	-5,71	-36,2%
Suture Traction	SBV3	Max Displacement Norm	1/mm	9	1,94	0,29	6	2,25	0,30	0,31	16,0%
Puncture	SP12	Unit Peak Force	N/mm	9	0,74	0,06	9	0,60	0,16	-0,14	-18,9%
Suture Traction	SP12	Ultimate Stress	N/mm²	7	13,84	2,77	10	9,10	1,79	-4,74	-34,2%
Suture Traction	SP12	Max Displacement Norm	1/mm	7	1,91	0,34	10	2,17	0,64	0,26	13,6%
Puncture	SP16	Unit Peak Force	N/mm	10	0,50	0,05	10	0,66	0,11	0,16	32,0%
Suture Traction	SP16	Ultimate Stress	N/mm²	9	9,20	2,41	9	13,37	5,14	4,17	45,3%
Suture Traction	SP16	Max Displacement Norm	1/mm	9	2,63	0,57	9	2,48	0,58	-0,15	-5,7%

- n refers to the accepted samples after IQR method application

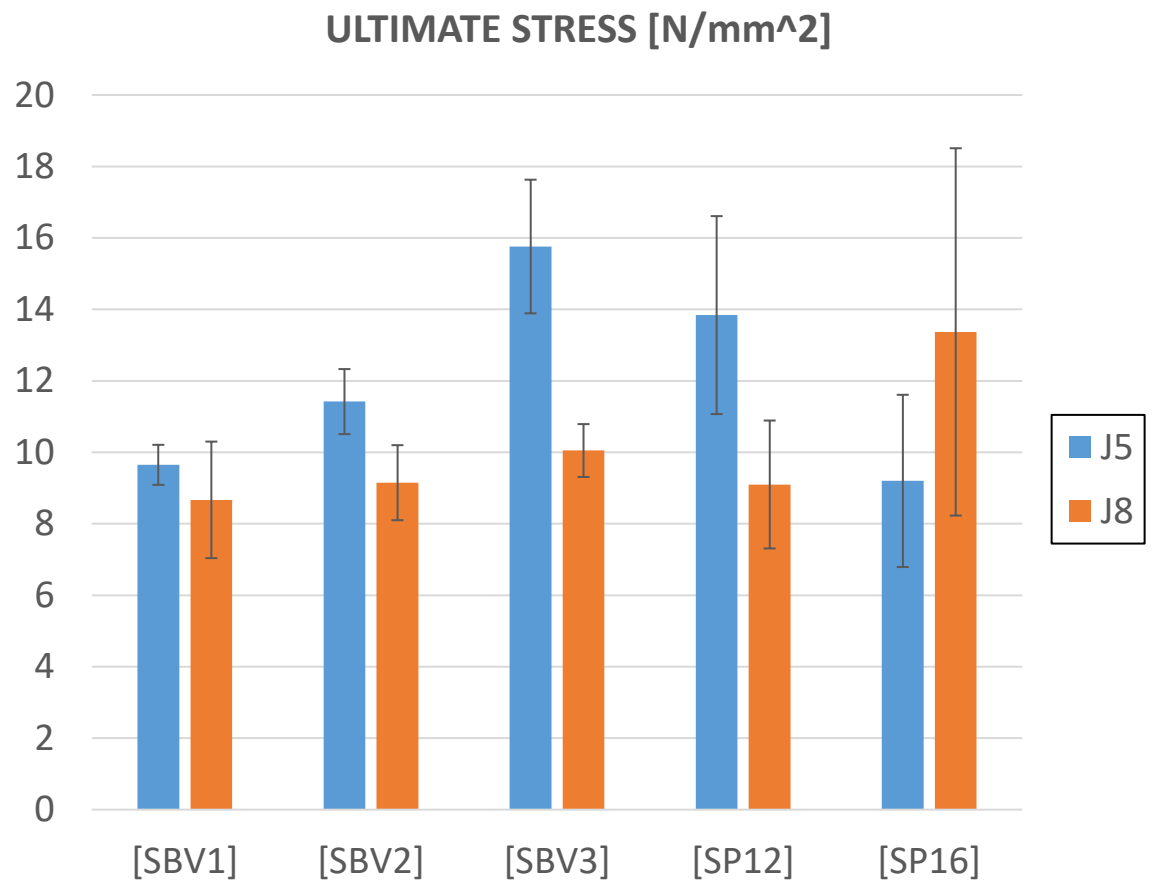
Puncture – Unit Peak Force



- SBV1,2,3 have the same core and a coating with an increasing % of TW (4,8,15%).
- From 4% to 8%, the effect is negligible, while visible in 15%
- J5 and J8 results are comparable (no statistical difference)
- When Elastico/Agilus % is >90% (SBV1, SBV2 and SP16), the puncture force of Elastico on average results more in line with the equivalent Agilus %
- When Elastico/Agilus % is 85% (SBV3 and SP12), then the Elastico-based mixtures seems to have a higher puncture force on average
- J8 results (Agilus based mixtures) show higher dispersion

Conclusion: the trend show an increase in puncture force with the reduction of Elastico/Agilus percentage. SPV2 is a comparable/slightly improved version of SP16, the same applies to SBV3 for SP12. Generally, SBV1 and SBV2 best candidates in terms of puncture force.

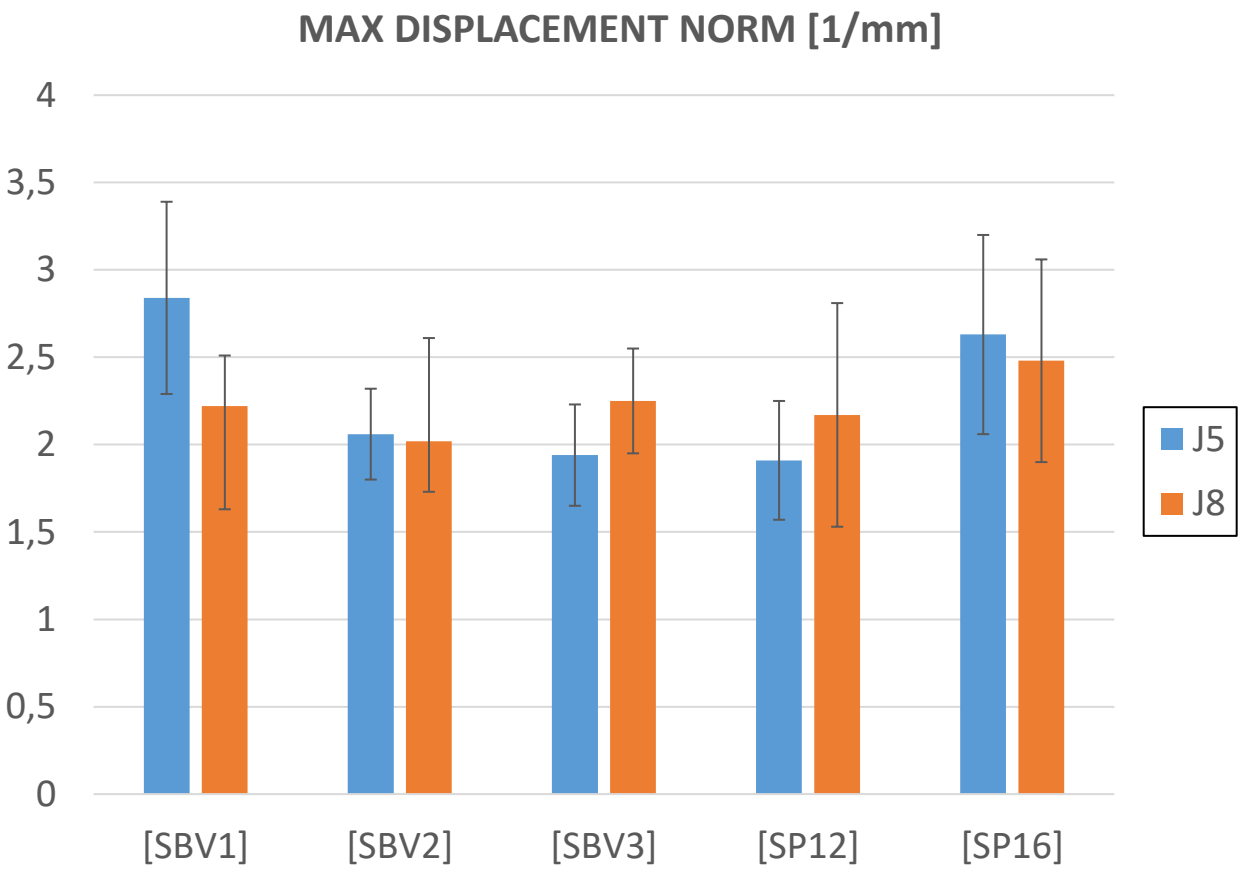
Suture Traction – Ultimate Stress



- SBV1,2,3 have the same core and a coating with an increasing % of TW (4,8,15%).
- The effect of an increased percentage of TW is clearly visible even between 4 and 8% on Elastico based mixtures (J5). The effect is less evident for Agilus based mixtures (J8)
- J5 and J8 results show a visible difference, which increase the more TW is added to the mixture
- SP16 has in general very high dispersion (on J8 in particular), which makes it even more resistance on average than SP12
- SBV2 vs SP16: the use of TW+Elastico outperform BM+Elastico. TW+Agilus seems to have lower performance than BM+Agilus, but SP16 has high dispersion rate
- SBV3 and SP12 are well aligned (TW seems to be quite comparable to CLR)

Conclusion: the trend show an increase in ultimate stress with the reduction of Elastico/Agilus percentage. Elastico based mixtures outperform SP12 and SP16, while Agilus based mixtures are comparable.

Suture Traction – Max Displacement



- SBV1,2,3 have the same core and a coating with an increasing % of TW (4,8,15%).
- The effect of an increased percentage of TW is very limited for both Elastico and Agilus based mixtures
- SBV2 vs SP16: the use of TW+Elastico/Agilus seems to make the mixture a little stiffer than BM+Elastico/Agilus
- SBV3 and SP12 are well aligned (TW seems to be quite comparable to CLR)
- SBV1: the higher percentage of Elastico/Agilus increase the elongation. Elastico outperform Agilus.

Conclusion: elongation is comparable. SBV2 is a little stiffer than SP16, SBV3 and SP12 are comparable. SBV1 has higher elongation, thanks to the higher percentage of Elastico/Agilus.

Conclusion - 1

According to the results obtained, we can draw the following conclusions on **J5**:

- SBV2 is a **good** candidate to replace SP16 → the new material will have higher ultimate stress (this means better withstanding of the suture traction) and the same puncture force. The material will be slightly stiffer, but the difference is negligible (2,06 vs 2,68)
- SBV3 is a **very good** candidate to replace SP12 → the new material will have higher ultimate stress (this means better withstanding of the suture traction) and the same puncture force and elongation.
- SBV1 is an interesting option to add a «Low Strenght Vessel» mixture: lower ultimate stress than SP12 and SP16, but slightly higher elongation (less marked than Elastico based mixtures).

* Please note that SBV1 has never been tested through applicative cases with surgeons

Conclusion - 2

According to the results obtained, we can draw the following conclusions on **J8**:

- SBV2 can be considered comparable to SP16 → the new material has on average a slightly lower ultimate force than SP16, but we have to consider the high dispersion rate of SP16 and the inversion of result on Ultimate Stress with respect to SP12. Puncture force is lower and the elongation a little reduced
- SBV3 is a **good** candidate to replace SP12 → the new material will have slightly higher ultimate stress and the same puncture force and elongation.
- SBV1 is an interesting option to add a «Low Strenght Vessel» mixture: lower ultimate stress than SP12 and SP16, but higher elongation.

* Please note that SBV1 has never been tested through applicative cases with surgeons

Conclusion - 3

Final remarks:

- TW is eligible to subtitute BM and CLR for suturable vessels mixtures
- TW-BM mixtures should be investigated to mitigate the increased stiffness introduced by TW (which is anyway limited)
- Analysis should be divided between J5 and J8 as Elastico and Agilus exhibit remarkable different behaviours

Thanks for Your Attention

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