

## SUPPLEMENTAL APPENDIX

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## **Methods**

### **RNA extraction and cDNA synthesis**

Total RNA extraction was performed from  $10^7$  cells using AllPrep Mini Kit (Qiagen, Hilden, Germany) according to the manufacturer's instructions. Reverse transcription reaction was run with 2 µg total RNA using TaqMan® Reverse transcription Kit (Applied Biosystems, Foster City, CA) and contained the following reagents: TaqMan® 10X RT Buffer (1x), MgCl<sub>2</sub> (5.5 mM), nucleoside triphosphates (2.5 mM), random hexamers (2.5 µM), RNase inhibitor (0.4 U/µl) and MultiScribe™ reverse transcriptase (1.25 U/µl). The total volume was 30 µl. Reaction

conditions were 25°C for 10 minutes (primer incubation), 48°C for 30 minutes (reverse transcription), and 95°C for 5 minutes (inactivation of reverse transcriptase).

### **RT-qPCR reaction**

RT-qPCR reactions were carried out using the MicroAmp™ Fast Optical 96-Well Reaction Plate (Applied Biosystems, Foster City, CA). The total volume for quantification of *RUNX1-RUNX1T1* or *B2M* transcript levels was 25 µl based on the following protocol: 2,5 µl cDNA, 12,5 µl TaqMan® Universal PCR Master Mix (2x), 3 pmol/µl of forward and reverse primers, as well as 1 pmol/µl of FAM/TAMRA labeled *RUNX1-RUNX1T1* or 2 pmol/µl of *B2M* probe, respectively. PCR conditions were: 50°C for 2 minutes and 95°C for 10 minutes (denaturation), followed by 50 cycles at 95°C for 15 seconds (annealing) and 60°C for 60 seconds (extension).

RT-qPCR analyses for *RUNX1-RUNX1T1* and *B2M* were performed in triplicates and included patient samples, negative template controls (NTC) and serial plasmid dilutions ( $10^2$ - $10^6$ ) for the respective genes. For sensitivity calculation, RNA of Kasumi-1 cell line (*RUNX1-RUNX1T1*-positive) and a patient sample were serially diluted in HL-60 cells (*RUNX1-RUNX1T1*-negative). In general, negativity of NTCs, correlation coefficient of the standard curve  $\geq 0.990$ , PCR efficiency of  $\geq 85\%$  and *B2M*  $\geq 50,000$  copy numbers were set as compulsory standards for each run. *RUNX1-RUNX1T1* transcript levels were reported as normalized values of *RUNX1-RUNX1T1* per  $10^6$  transcripts of the housekeeping gene *B2M* [*RUNX1-RUNX1T1* transcript levels/*B2M* transcript levels  $\times 10^6$ ]. As previously published by our group, the following equation was applied for calculation of *RUNX1-RUNX1T1* and *B2M* transcript levels:  $10^{(C_t - Y)/S}$  [C = average cycle threshold ( $C_t$ ) value from triplicates; Y = Y-intercept; S = slope of the standard curve].<sup>1</sup> RT-qPCR negativity was defined as  $C_t > Y$ -intercept. The maximum sensitivity of our assay was  $10^{-6}$ . All procedures are accredited under the DIN EN ISO/IEC 17025:2005 and DIN EN ISO 15189:2014 of the Deutsche Akkreditierungsstelle GmbH.

### **Statistical Analyses**

The definition of CR, relapse, event-free survival (EFS), relapse-free survival (RFS), and overall survival (OS) were based on recommended criteria.<sup>2</sup> The cumulative incidence of relapse (CIR) was calculated according to Gray.<sup>3</sup> Survival times were calculated from the date the MRD sample was obtained. The median follow-up for survival was calculated according to the method of Korn.<sup>4</sup> Logistic and Cox proportional hazards models were used to identify

prognostic variables for CR, OS, and CIR.<sup>5,6</sup> For *RUNX1-RUNX1T1* transcript levels, a  $\log_{10}$  transformation of the data was performed (hazard ratio [HR] for 10-fold higher value). In addition,  $\log_{10}$  transformation necessitated substitution of 0 by the first *RUNX1-RUNX1T1* transcript level defined as negative, 0.33. Additional covariables in multivariable analysis were age, BM blast counts, lactate dehydrogenase (LDH) serum levels, white blood cell counts (WBC) as continuous variable, and *KIT* mutation status as dichotomous variable. Determining cut-off values of prognostic factors in survival data with competing risks was done based on maximally selected log-rank statistics.<sup>7</sup> Comparisons of the distribution of *RUNX1-RUNX1T1* transcript levels according to qualitative group variables were performed using the Mann-Whitney U test. Correlations between continuous variables were calculated using the Spearman rank test. Survival distributions were calculated using the Kaplan-Meier method, and differences between two groups were analyzed using the two-sided log-rank test. Cumulative incidence functions were compared using Gray's test. An effect was considered significant if  $P < 5\%$ . All statistical analyses were performed with the statistical software environment R version 3.2.1, using the R packages rms version 4.1-1, survival version 2.41-3, cmprsk version 2.2-7, and IBM SPSS Statistics 25.

## References

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**Supplemental Table T1.** Distribution of BM and PB samples during therapy and follow-up.

**Number of samples:**

<b>Time point</b>	<b>BM samples, n</b>	<b>PB samples, n</b>
<b>Diagnosis</b>	<b>145</b>	<b>135</b>
<b>Cycle 1</b>	<b>111</b>	<b>91</b>
<b>Cycle 2</b>	<b>110<sup>§</sup></b>	<b>101<sup>#</sup></b>
<b>Cycle 3</b>	<b>105</b>	<b>87</b>
<b>Cycle 4</b>	<b>99</b>	<b>95</b>
<b>Cycle 5</b>	<b>73</b>	<b>62</b>
<b>Cycle 6</b>	<b>8</b>	<b>7</b>
<b>End of treatment (EOT)</b>	<b>99</b>	<b>86</b>
<b>3 months (after EOT)</b>	<b>78</b>	<b>72</b>
<b>6 months (after EOT)</b>	<b>61</b>	<b>53</b>
<b>9 months (after EOT)</b>	<b>47</b>	<b>44</b>
<b>12 months (after EOT)</b>	<b>46</b>	<b>46</b>
<b>15 months (after EOT)</b>	<b>36</b>	<b>39</b>
<b>18 months (after EOT)</b>	<b>41</b>	<b>46</b>
<b>21 months (after EOT)</b>	<b>31</b>	<b>33</b>
<b>24 months (after EOT)</b>	<b>23</b>	<b>26</b>
<b>27 months (after EOT)</b>	<b>14</b>	<b>17</b>
<b>30 months (after EOT)</b>	<b>18</b>	<b>19</b>
<b>33 months (after EOT)</b>	<b>7</b>	<b>9</b>
<b>36 months (after EOT)</b>	<b>11</b>	<b>18</b>
<b>39 months (after EOT)</b>	<b>5</b>	<b>5</b>
<b>42 months (after EOT)</b>	<b>6</b>	<b>9</b>
<b>45 months (after EOT)</b>	<b>4</b>	<b>6</b>
<b>48 months (after EOT)</b>	<b>4</b>	<b>9</b>

Abbreviations: EOT, end of treatment; BM, bone marrow; PB, peripheral blood. <sup>§</sup>60 patients received induction II, 50 patients received consolidation I; <sup>#</sup>58 patients received induction II, 43 patients received consolidation I.

**Supplemental Table T2: Baseline characteristics and outcome according to trial cohorts.**

Study	HD98A <sup>#</sup> (n=14)	AMLSG 07-04 <sup>#</sup> (n=43)	AMLSG 11-08 <sup>§</sup> (n=32)	AMLSG 21-13 <sup>§</sup> (n=45)	Other (n=21)	P value
Median age, years (range)	42 (19 – 59)	38 (18 – 57)	52 (27 – 73)	50 (21 – 76)	56 (19 – 72)	0.0002
Male sex, n (%)	9 (64)	23 (53)	18 (56)	26 (58)	10 (48)	0.8882
<b>AML history, n (%)</b>						
<i>De novo</i>	14 (100)	41 (95)	27 (84)	33 (89)	17 (85)	0.5118
Secondary	0 (0)	0 (0)	1 (3)	1 (3)	0 (0)	
Therapy-related	0 (0)	2 (5)	4 (13)	3 (8)	3 (15)	
Missing data, n	0	0	0	8	1	
Median WBC, x 10 <sup>9</sup> /l (range)	9.3 (1.0 – 60.5)	10.0 (1.2 – 48.2)	9.0 (1.4 – 45.7)	7.8 (1.6 – 118)	7.7 (1.9 – 45)	0.8269
Missing data, n	0	1	0	7	1	
Median platelet count, x 10 <sup>9</sup> /l (range)	37 (16 – 226)	23 (5 – 303)	32 (8 – 279)	34 (5 – 246)	32 (3 – 119)	0.7152
Missing data, n	0	1	0	7	1	
Median hemoglobin, g/dl (range)	8.7 (4.2 – 14.8)	8.8 (4.6 – 15.1)	9.2 (5.2 – 13.2)	8.9 (3.8 – 12.5)	9.0 (4.8 – 11.2)	0.2194
Missing data, n	0	1	0	7	1	
Median peripheral blood blasts, % (range)	52 (16 – 90)	47 (4 – 99)	35 (0 – 85)	39 (0 – 82)	40 (0 – 79)	0.3820
Missing data, n	1	4	1	11	1	
Median bone marrow blasts, % (range)	45 (6 – 85)	65 (20 – 100)	60 (13 – 95)	50 (15 – 100)	58 (17 – 91)	0.2412
Missing data, n	3	0	1	8	2	
Median LDH, U/l (range)	530 (213 – 1,662)	476 (138 – 3,550)	484 (226 – 1,968)	428 (5 – 1,910)	417 (205 – 4,420)	0.6610
Missing data, n	9	1	0	7	0	
<i>KIT</i> mutation, n (%)	4 (29)	17 (41)	6 (19)	7 (21)	5 (28)	0.2204
Missing data, n	0	2	1	11	3	
<i>FLT3</i> -ITD/TKD mutation, n (%)	1 (7)	3 (8)	3 (9)	4 (9)	3 (14)	0.9348
Missing data, n	0	4	0	0	0	
<i>NRAS</i> mutation, n (%)	2 (14)	8 (20)	6 (19)	6 (17)	2 (11)	0.9435
Missing data, n	0	2	0	10	3	
<i>ASXL2</i> mutation, n (%)	6 (46)	7 (17)	2 (7)	0 (0)	3 (23)	0.0240
Missing data, n	1	1	3	45	8	
<b>Response</b>						
CR after cycle I	9 (64)	35 (81)	26 (81)	35 (78)	14 (67)	0.5046
RD after cycle I	1 (7)	2 (5)	0 (0)	0 (0)	0 (0)	
PR after cycle I	4 (29)	6 (14)	6 (19)	10 (22)	7 (33)	

<b>CR after cycle II</b>	14 (100)	43 (100)	32 (100)	42 (98)	21 (100)	0.9544
<b>RD after cycle II</b>	0 (0)	0 (0)	0 (0)	1 (2)	0 (0)	
<b>Outcome</b>						
<b>OS</b>						0.2992
<b>Median, years</b>	4.95	NR	NR	NR	NR	
<b>3-year survival rate (%)</b>	57	84	71	78	77	
<b>4-year survival rate (%)</b>	57	80	71	NR	77	
<b>EFS</b>						0.6568
<b>Median, years</b>	1.52	7.95	NR	NR	NR	
<b>3-year survival rate (%)</b>	50	67	68	70	58	
<b>4-year survival rate (%)</b>	43	67	68	NR	58	
<b>RFS</b>						0.5165
<b>Median, years</b>	1.27	7.87	NR	NR	NR	
<b>3-year survival rate (%)</b>	50	70	68	69	54	
<b>4-year survival rate (%)</b>	43	70	68	NR	54	

# included patients 18 to 60 years; § included patients ≥18 years (no age limit)  
NR, not reached

**Supplemental Table T3:** Multivariable analysis for response to induction I.

	<b>CR after cycle 1</b>	
	<b>OR (95% CI)</b>	<b>P</b>
	<b>n=120</b>	
<b>Log<sub>10</sub>TL diagnosis BM</b>	0.93 (0.32-2.72)	0.895
<b><i>KIT</i><sup>mut</sup></b>	0.28 (0.11-0.76)	0.012
<b>Age</b>	1.00 (0.97-1.04)	0.936
<b>BM blasts</b>	1.01 (0.99-1.03)	0.258
<b>LDH</b>	1.00 (1.00-1.00)	0.055
<b>WBC</b>	0.98 (0.95-1.02)	0.984

**Supplemental Table T4:** Multivariable analysis determining the prognostic significance of MR<sup>3.0</sup> after cycle 2 in BM and PB.

	<b>Relapse</b>	
	<b>HR (95% CI)</b>	<b>P</b>
	<b>n=92</b>	
<b>Transcript level reduction after cycle 2</b>		
<b>BM</b>		
<b>MR<sup>3.0</sup></b>	0.48 (0.24-0.98)	0.043
<b><i>KIT</i><sup>mut</sup></b>	2.03 (0.97-4.22)	0.059
<b>Age</b>	1.00 (0.97-1.03)	0.959
<b>BM blasts</b>	1.00 (0.98-1.01)	0.773
<b>LDH</b>	1.00 (1.00-1.00)	0.983
<b>WBC</b>	1.00 (0.98-1.03)	0.971
	<b>n=81</b>	
<b>PB</b>		
<b>MR<sup>3.0</sup></b>	0.35 (0.14-0.85)	0.021
<b><i>KIT</i><sup>mut</sup></b>	1.72 (0.77-3.83)	0.184
<b>Age</b>	1.00 (0.97-1.03)	0.875
<b>BM blasts</b>	1.01 (0.99-1.02)	0.626
<b>LDH</b>	1.00 (1.00-1.00)	0.525
<b>WBC</b>	1.01 (0.99-1.03)	0.262



**Supplemental Table T5:** Multivariable analyses stratified according to dasatinib treatment determining the prognostic significance of *RUNX1-RUNX1T1* transcript levels, MRD cut-off values, and MRD<sup>neg</sup> at EOT in BM and PB.

Transcript Level	Death		Relapse	
	HR (95% CI)	P	HR (95% CI)	P
	<b>n=81</b>		<b>n=82</b>	
<b>BM</b>				
Log <sub>10</sub> TL	1.71 (1.12-2.62)	0.013	1.76 (1.21-2.54)	0.003
<i>KIT</i> <sup>mut</sup>	2.87 (0.97-8.48)	0.056	2.08 (0.84-5.13)	0.114
Age	1.02 (0.98-1.07)	0.362	1.00 (0.97-1.04)	0.909
BM blasts	0.99 (0.97-1.01)	0.368	1.00 (0.98-1.02)	0.977
LDH	1.00 (1.00-1.00)	0.938	1.00 (1.00-1.00)	0.769
WBC	1.03 (1.00-1.05)	0.064	1.01 (0.97-1.04)	0.754
<b>PB</b>	<b>n=71</b>		<b>n=72</b>	
Log <sub>10</sub> TL	1.61 (1.06-2.43)	0.025	2.91 (1.79-4.74)	<0.001
<i>KIT</i> <sup>mut</sup>	4.33 (1.41-13.31)	0.011	3.07 (1.24-7.60)	0.015
Age	1.01 (0.97-1.06)	0.595	1.00 (0.97-1.04)	0.811
BM blasts	0.99 (0.97-1.02)	0.564	1.01 (0.99-1.03)	0.522
LDH	1.00 (1.00-1.00)	0.898	1.00 (1.00-1.00)	0.570
WBC	1.02 (0.99-1.05)	0.220	1.00 (0.97-1.04)	0.813
<b>Specific cut-off values</b>	<b>n=81</b>		<b>n=82</b>	
<b>BM</b>				
Absolute TL >83	4.88 (1.47-16.26)	0.010	3.98 (1.60-9.89)	0.003
<i>KIT</i> <sup>mut</sup>	2.62 (0.86-8.02)	0.091	2.07 (0.84-5.09)	0.112
Age	1.03 (0.98-1.08)	0.207	1.01 (0.98-1.05)	0.506
BM blasts	0.99 (0.97-1.01)	0.382	1.00 (0.98-1.02)	0.991
LDH	1.00 (1.00-1.00)	0.828	1.00 (1.00-1.00)	0.747
WBC	1.02 (1.00-1.05)	0.076	1.01 (0.98-1.04)	0.754
<b>PB</b>	<b>n=71</b>		<b>n=72</b>	
Absolute TL >5	3.36 (1.06-10.66)	0.040	5.40 (2.01-14.51)	0.001
<i>KIT</i> <sup>mut</sup>	3.92 (1.29-11.88)	0.016	3.12 (1.27-7.66)	0.013
Age	1.01 (0.97-1.05)	0.750	1.00 (0.97-1.03)	0.961
BM blasts	1.00 (0.97-1.02)	0.756	1.00 (0.98-1.02)	0.682
LDH	1.00 (1.00-1.00)	0.701	1.00 (1.00-1.00)	0.473
WBC	1.02 (0.99-1.05)	0.181	1.01 (0.98-1.04)	0.679
<b>MRD<sup>neg</sup></b>	<b>n=81</b>		<b>n=82</b>	
<b>BM</b>				
MRD <sup>neg</sup>	0.22 (0.05-0.88)	0.033	0.39 (0.15-0.97)	0.042
<i>KIT</i> <sup>mut</sup>	2.48 (0.84-7.34)	0.100	2.13 (0.88-5.15)	0.094
Age	1.01 (0.97-1.06)	0.565	1.00 (0.97-1.04)	0.924
BM blasts	0.99 (0.97-1.02)	0.503	1.00 (0.98-1.02)	0.836
LDH	1.00 (1.00-1.00)	0.986	1.00 (1.00-1.00)	0.782
WBC	1.03 (1.00-1.05)	0.076	1.00 (0.97-1.04)	0.864
<b>PB</b>	<b>n=71</b>		<b>n=72</b>	
MRD <sup>neg</sup>	0.28 (0.09-0.81)	0.019	0.37 (0.16-0.87)	0.022
<i>KIT</i> <sup>mut</sup>	3.44 (1.12-10.54)	0.031	2.24 (0.95-5.30)	0.067
Age	1.01 (0.97-1.05)	0.628	1.01 (0.98-1.04)	0.576
BM blasts	0.99 (0.97-1.02)	0.596	1.00 (0.98-1.02)	0.999
LDH	1.00 (1.00-1.00)	0.813	1.00 (1.00-1.00)	0.789
WBC	1.02 (0.99-1.05)	0.189	1.00 (0.97-1.03)	0.848

Abbreviations: MRD<sup>neg</sup>, MRD negativity; EOT, end of treatment; BM, bone marrow; PB, peripheral blood; HR, hazard ratio; CI, confidence interval; P, p-value; n, number of patients included in the analysis; TL, transcript levels; *KIT*<sup>mut</sup>, mutated *KIT* gene; LDH, lactate dehydrogenase; WBC, white blood cell count

**Supplemental Table T6:** Impact of additional dasatinib treatment on MRD<sup>neg</sup> at EOT.

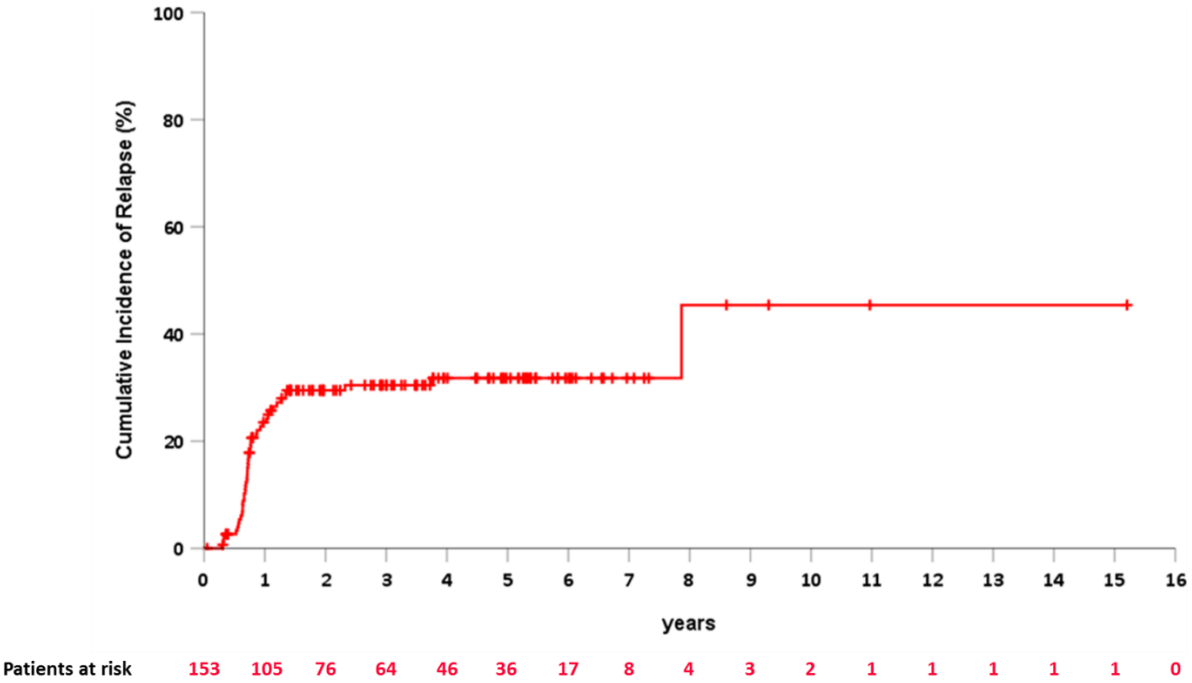
	Dasatinib (pt no)	No Dasatinib (pt no)	P value
<b>EOT BM (n=99)</b>			
<b>MRD<sup>neg</sup> EOT BM</b>	24	27	0.0608
<b>MRD<sup>pos</sup> EOT BM</b>	13	35	
<b>EOT PB (n=86)</b>			
<b>MRD<sup>neg</sup> EOT PB</b>	28	36	0.0113
<b>MRD<sup>pos</sup> EOT PB</b>	3	19	

**Supplemental Table T7:** Impact of additional dasatinib treatment on outcome.

Dasatinib treatment	OS		CIR	
	HR (95% CI)	P	HR (95% CI)	P
<b>BM</b>				
After Cycle 1	0.95 (0.45-1.99)	0.881	0.49 (0.20-1.08)	0.077
After Cycle 2	0.82 (0.36-1.89)	0.644	0.54 (0.24-1.19)	0.124
At EOT	0.89 (0.33-2.40)	0.814	0.75 (0.32-1.75)	0.509
<b>PB</b>				
After Cycle 1	1.19 (0.48-2.96)	0.710	0.68 (0.30-1.57)	0.369
After Cycle 2	1.21 (0.48-3.02)	0.691	0.87 (0.40-1.88)	0.718
At EOT	0.49 (0.16-1.51)	0.216	0.67 (0.29-1.54)	0.345

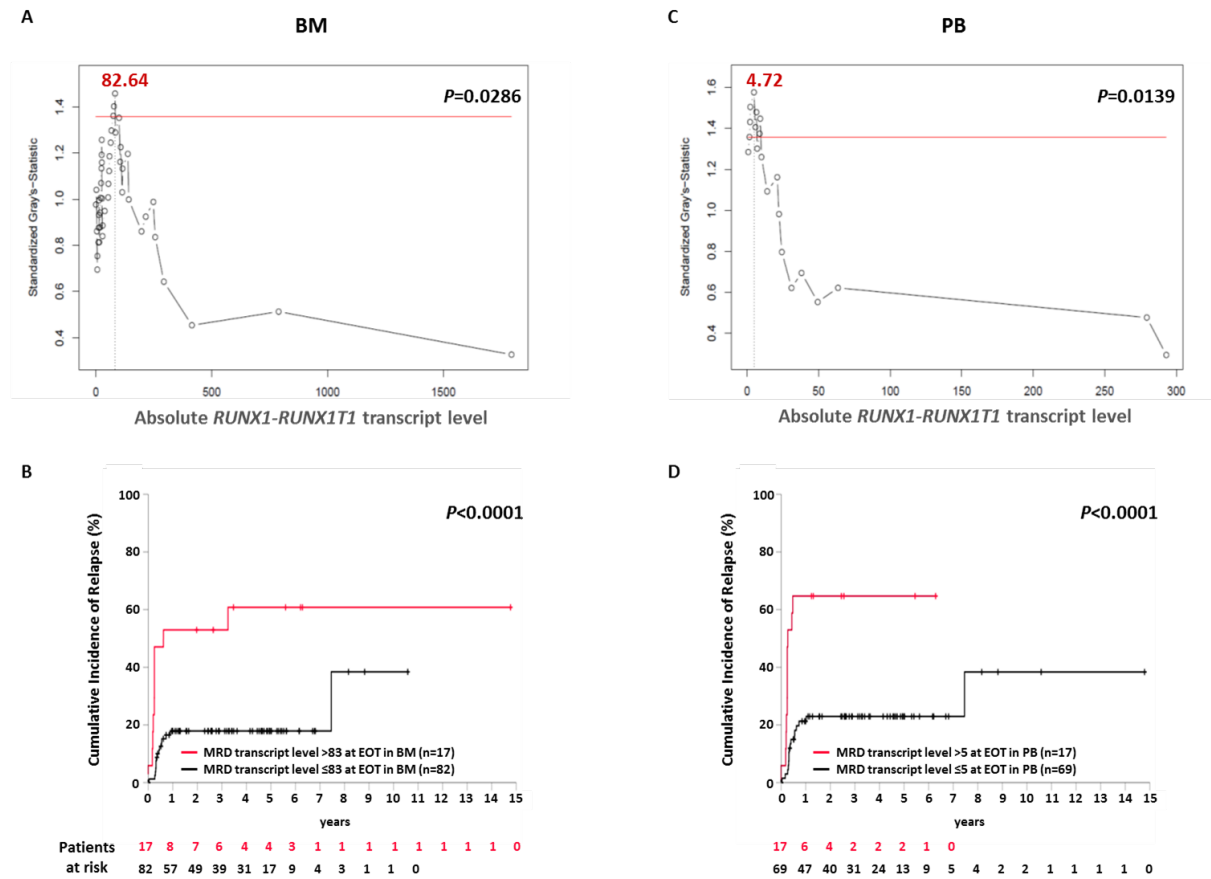
**Supplemental Figure F1**

Cumulative incidence of relapse (CIR) of the 155 *RUNX1-RUNX1T1*-positive AML patients.



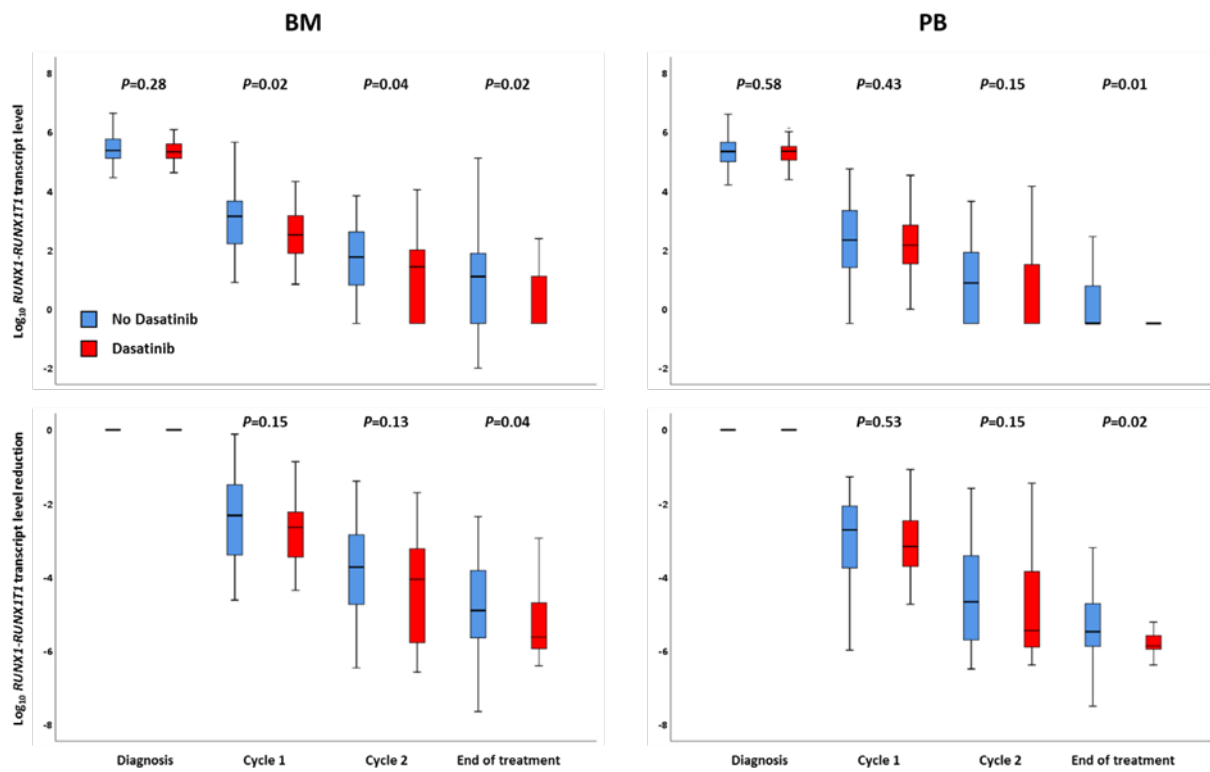
**Supplemental Figure F2:**

Maximally selected Gray's statistic for competing risks delineated cut-offs at EOT being associated with a low risk of relapse. For BM, MRD level below 83 *RUNX1-RUNX1T1* transcript level predicted for superior 4-year rates of CIR (18% vs 61%;  $P<0.0001$ ) (A and B). For PB, MRD level below 5 *RUNX1-RUNX1T1* transcript level predicted for superior 4-year rates of CIR (23% vs 65%;  $P<0.0001$ ) (C and D).



### Supplemental Figure F3:

Impact of additional dasatinib treatment on MRD kinetics.  $\text{Log}_{10}$  *RUNX1-RUNX1T1* transcript levels (upper panel) and the reduction of *RUNX1-RUNX1T1* transcript levels (lower panel) are shown for BM (left) and PB (right) during the course of treatment.



**Supplemental Figure F4:**

Cumulative incidence of relapse (CIR) during follow-up based on defined MRD cut-offs in BM and PB according to additional dasatinib treatment (B and D).

