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LETTER TO THE EDITOR

A mouse model of disseminated mantle cell lymphoma highlights a lack of activity of estrogen receptor β agonists toward tumor burden

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Running head : Lack of ER β agonist activity on MCL

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Estrogens regulate numerous physiological processes through their binding to estrogen receptors (ER) of α and β -types. However, while activated ER α enhances cell proliferation, activated ER β inhibits cell proliferation and induces apoptosis. Normal and malignant immune cells express both types of ER but predominantly ER β [4]. This property has been successfully used to selectively inhibit growth and induce apoptosis in an *in vivo* model of lymphoma [5]. In this study, the Granta519 mantle cell lymphoma (MCL) cell line was engrafted s.c. into *nude* mice. Treatment of mice with diarylpropionitrile (DPN) led to the inhibition of tumor cell growth. The biological effects of DPN were mediated by the inhibition of BAFF (B-cell activating factor) and GBR7 (growth factor receptor-bound protein 7) survival factors, and VEGF (vascular endothelial growth factor or VEGF), an angiogenic factor.

According to the dependency of MCL cells with their TME, we suspected that MCL tumor cells-stroma interactions would not be the same for MCL cells engrafted s.c. or in their physiological niche. We engineered four cell lines: JeKo1-mCherry-Luc, Z138-Luc, REC1-GFP-Luc and Granta519-GFP from their respective parental cell lines. Cells were then injected i.v. into NOD-SCID IL2R γ null (NSG) mice (n = 6). All animals recapitulated *bona fide* MCL disease. Tumor cells having luciferase activity were detected by bioluminescence imaging (BLI) with a

kinetics dependent of each cell line: JeKo1 being the most aggressive and REC1 the less aggressive cells (Fig S1). BLI examination indicated that tumor cells housed in hematopoietic organs (bone marrow, spleen) and, in some cases, in non-hematopoietic organs (liver, lung, kidney). The identity of tumor cells was verified at the time of mice euthanasia by cytometry analysis of CD20+ cells purified from infiltrated organs (Table 1).

We analyzed the expression of ER α and ER β on a panel of MCL cells both at the mRNA and protein levels. ER α mRNAs were absent or very low in all cell lines (data not shown) according to previous data [5]. In contrast, ER β was expressed in all MCL cell lines (including GFP/mCherry/Luc expressing JeKo1, Granta519, REC1 and Z138 cells) tested although at various levels (Fig 1A). We next assessed *in vivo* the effects of both DPN and ERB-041 (or 2-(3-Fluoro-4-hydroxyphenyl)-7-vinyl-1,3-benzoxazol-5-ol), another selective ER β agonist [6], on MCL dissemination and growth. Z138-Luc or REC1-GFP-Luc cells were injected in NSG mice. The same day, mice were separated into three groups (n = 3) receiving: vehicle (0.01% DMSO), DPN or ERB-041 both at the concentration of 1 mg/kg. Drugs and vehicle were injected i.p. 5 days a week. BLI was recorded each week starting at day 7. Mice were euthanized at day 31 (Z138-Luc) or day 41 (REC1-GFP-Luc). As shown Fig 1B, DPN or ERB-041 treatments did not modify the engraftment properties of MCL tumor cells, since all mice were engrafted with luciferase-positive cells, or their homing, since infiltrated organs were the same among the different groups. Moreover, the number of CD45+ tumor cells in each organ was also similar between the three groups (Fig S2). In sharp contrast with published data [5], ER β agonists have no effects on tumor cells growth in this *in vivo* model. *In vitro*, although DPN was more active than ERB-041 and, Granta519 being the cell line with the highest sensitivity, we did not observed any dose-dependent effect of ER β agonists on cell proliferation (Fig S3).

One main action of DPN is to counteract migration and invasion [5]. We next tested the effect of ERB-041 and DPN on MCL cells in two *in vitro* assays : one dedicated to chemotaxis, the other one to invasion. Our data indicated clearly that ERB-041 and DPN had no inhibitory effects on migration (Fig 1C and Fig S4A) or invasion (Fig S4B).

Finally, since DPN was reported to inhibit VEGF synthesis [5], we looked at the effects of DPN and ERB-041 on angiogenesis using the tube formation assay. As shown Fig 1D and Fig S5, the density of tubes was similar in the ER β - and vehicle-targeted groups. ER β agonists had no effect on the formation of structures resembling a microvasculature bed. We then measured VEGF synthesis in conditioned medium of cultured MCL cells treated with ER β agonists or vehicle using ELISA (Fig S2C, Fig 1E). Our data confirmed that the quantity of VEGF secreted MCL tumor cells remained the same after DPN or ERB-041 treatments.

Subcutaneous injections are commonly used for the engraftment of human MCL cells in immunocompromised mice. However, this model is imperfect and does not recapitulate the interactions between the TME and tumor cells. In this study, we present a convenient and reproducible *in vivo* model that reproduces human MCL pathology. After i.v. injection of engineered luciferase-expressing MCL cell lines, we observed that tumor cells preferentially colonize hematopoietic organs such as bone marrow and spleen, and other common metastatic sites such as brain and gut. The lack of *in vivo* effect of ER β agonists in this pre-clinical model could be due to a protective CAM-DR. Indeed, in this *in vivo* model, MCL cells are in close contact with stromal cells delivering anti-apoptotic and pro-proliferative signals likely bypassing the effect of the drugs [7]. Alternatively, the pharmacokinetics distribution of ER β agonists may be different in the model described here and the one of Yakimchuk and colleagues [5]. A low concentration of ER β agonists could be present in the physiologic niches such as the bone marrow explaining the lack of efficiency for the treatment. Finally,

the anti-angiogenic properties of ER β agonists highlighted in the work of Yakimchuk and colleagues [5], may have a greater impact on the proliferation of tumor cells in the s.c. model, where the neovascularization is crucial to bring to the tumor nutrients and oxygen. By contrast, hematopoietic organs are less dependent on neovascularization. However, our *in vitro* experiments confirmed that, although ER β are well-expressed in the MCL cell lines, ER β agonists had no effect on proliferation, migration, invasion or VEGF production, emphasizing the *in vivo* results. Interestingly, we found previously that, although able to decrease multiple myeloma cell proliferation, ER β agonists are inefficient *in vivo* [8]. In conclusion, our results highlight a lack of effects of ER β agonists as single agents in mice. Nonetheless, as it has been described that estrogen play an important role in BCR pathway regulation [9], consequently further investigations would be required to assess the efficacy of ER β agonists in association with B-cell receptor inhibitors, like ibrutinib.

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The authors declare no conflicts of interest.

Authors contribution

SB, AE-A, and CR-Z performed the research and analyzed the data. XT provided essential support. GR and BS designed and supervised the study. SB and BS wrote the paper. All authors read the final version of the manuscript and agree with its content and submission.

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Figure 1. ERβ are present on MCL cells but ERβ agonists do not affect migration, invasion, nor angiogenesis

A. Proteins were purified from cultured MCL cell lines including GFP/mCherry/Luc-expressing cells with the M-PER™ Mammalian Protein Extraction Reagent (Thermo Fisher Scientific), quantified, separated by SDS-PAGE, blotted onto nitrocellulose mambrane and incubated with antibodies against ERβ (sc-8974, Santa Cruz Biotech.) or β-actin (sc-47778) as a control for gel loading and transfer. Our procedure has been described previously [10]. A band at 55 kDa, specific for ERβ, is arrowed; * refers to an unspecific band at 75 kDa. **B.** *In vivo* experiments were conducted in accordance with the recommendations of EEC (86/609/CEE) and with the approval of the Animal Experimental Ethics Committee of our institution (UB-CEEA agreement 251/15). Z138-GFP-Luc, REC1-GFP-Luc, JeKo1-mCherry-Luc, and Granta519-GFP cell lines were engineered using lentivirus or retrovirus infections. Male NSG mice, n = 3 per group (age 6-8 weeks), were injected i.v. with 10⁷ cells in a final volume of 100 μl. The same day, mice were separated into three groups receiving: vehicle (0.01% DMSO), DPN or ERB-041 both at the concentration of 1 mg/kg. Drugs and vehicle were injected i.p. 5 days a week. Tumor engraftment was determined weekly by bioluminescence imaging (BLI). For this aim, mice were injected i.p. with 75 mg/kg of D-luciferine and then analyzed on an Aequoria Luxiflux bioluminescent device equipped with an ORCA-ER camera (Hamamatsu). Mice were euthanized at day 31 (Z138-Luc) or day 41 (REC1-GFP-Luc). Endpoint BLI signal is shown for each treatment group. **C.** MCL cells were treated *in vitro* with DPN or ERB-041 (100 nM or 1 μM for 48 h or 72 h) or vehicle and assayed for migration.

Cells (5×10^5 cells per insert) were suspended in RPMI 1640 medium containing 0.5% bovine serum albumin (BSA). They were seeded in the top chamber of transwell inserts (Millicell® Hanging Cell Culture Inserts 5 μ m PET, Millipore). Filters were transferred to wells containing RPMI 1640 medium with recombinant human stromal cell-derived factor 1 (SDF1, 200 ng/ml, R&D Systems) as chemoattractant. Plates were then incubated for 4 h at 37°C, and the number of cells migrated in the lower chambers was counted by flow cytometry. As an example, the results obtained for the Z138 cell line treated with 0.1 or 1 μ M ERB-041 or DPN for 48 h are shown. The percentage of migrating cells (treated vs. vehicle) for each culture condition is plotted on the graph. **D.** HUVECs were plated onto a layer of Matrigel (BD Bioscience) at a density of 4×10^4 cells/well. Cells were treated with supernatants of ERB-041-treated (100 nM or 1 μ M for 4 h) or vehicle-treated cells as a control. After 24 h, tubular structures were photographed under a microscope (Olympus IX2-SL). The number of formed capillary tubes was counted in 11 independent fields (Fig S5A) of each well from each culture. The experiment has been done twice with triplicate samples. The number of tubes are plotted in the histograms. **E.** The concentration of VEGF was measured with an ELISA assay (Quantikine ELISA Human VEGF, R&D systems) using the supernatants of Granta519 and JeKo-1 cells treated by ERB-041 (1 μ M for 48 h) according to the manufacturer's recommendations. Samples were assayed in triplicate. The concentration of synthesized VEGF in each culture condition was deduced from the standard curve shown in Fig S5B. ns, non significant; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$ with the Student's *t*-test.

Table 1. Flow cytometry analysis of infiltrated organs in engrafted NSG mice

Cell line	Mouse	Spleen	Blood	Bone marrow	Liver	Lung	Kidney	Testis
JeKo1-mCherry-Luc*	J1	5	no	44	no	nd	nd	no
	J2	15	no	59	no	nd	nd	no
	J3	7	7	45	no	nd	nd	no
Z138-Luc**	Z3	22	no	68	no	nd	nd	nd
	Z4	24	no	75	no	nd	nd	nd
	Z5	38	no	82	no	nd	nd	nd
REC1-GFP-Luc***	R4	no	no	4	nd	nd	nd	nd
	R5	no	no	3	no	nd	nd	nd
	R6	no	no	3	nd	nd	nd	nd
Granta519-GFP†	G1	23	1	57	45	7	9	no
	G4	37	2	21	47	3	10	< 1

*, in the JeKo1-mCherry-Luc series, three mice were sacrificed at day 23. **, in the Z138-Luc series, three mice were sacrificed at day 30. ***, in the REC1-GFP-Luc series, three mice were sacrificed at day 33.†, in the Granta-GFP series, three mice died unexpectedly at day 17, two mice were sacrificed at the same day. At the time of euthanasia, indicated organs were collected; single-cell suspensions were prepared, then stained with IOTest® CD20-PE (phycoerythrin, IM1451, FL2) or the corresponding isotype control and analyzed on an Attune acoustic focusing cytometer (Thermo Fisher Scientific). The percentage of positive cells in each organ is indicated in the table. no, no signal; nd, not done.

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Running head : Lack of ER β agonist activity on MCL

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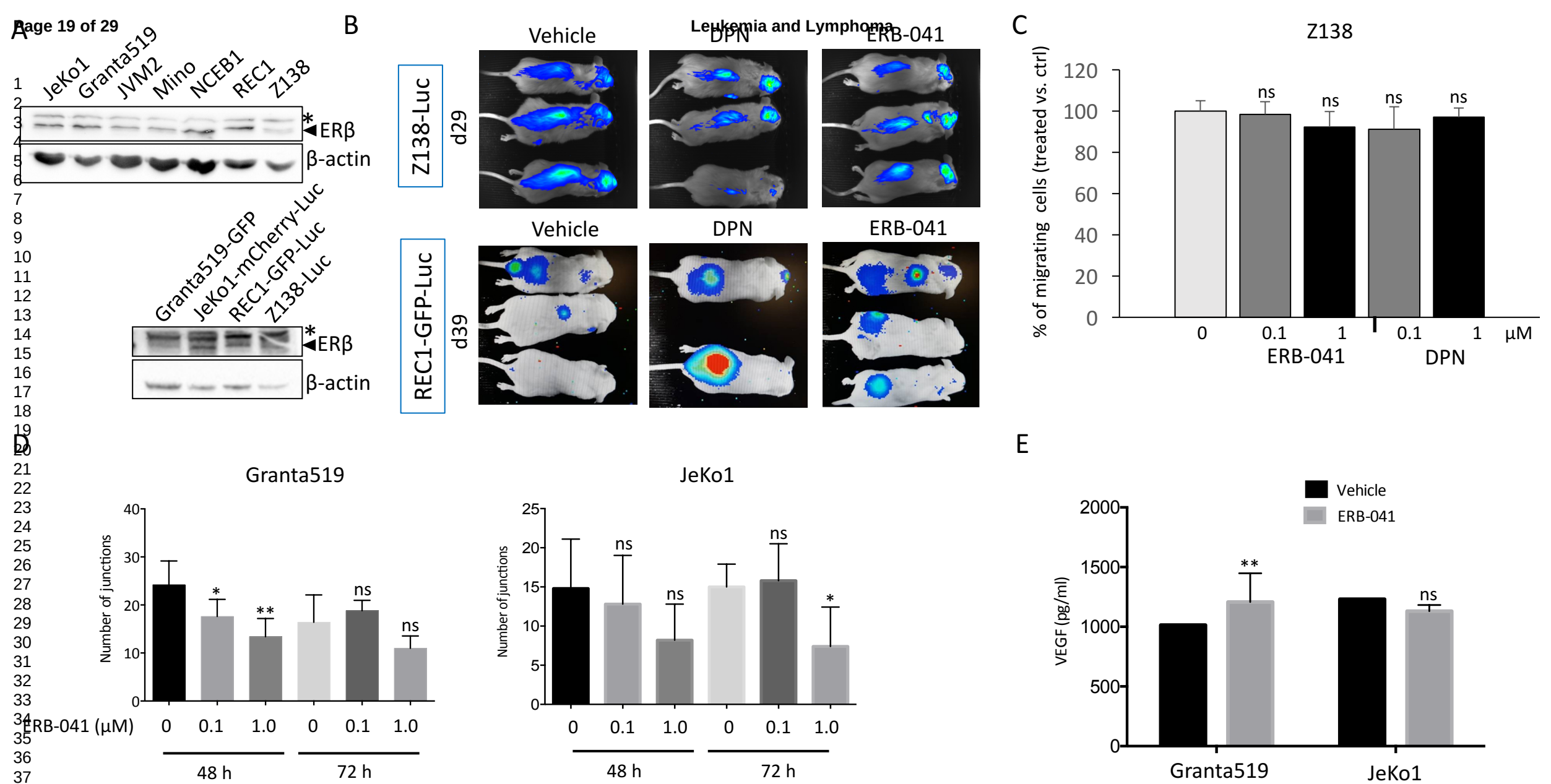
A. Proteins were purified from cultured MCL cell lines including GFP/mCherry/Luc-expressing cells with the M-PER™ Mammalian Protein Extraction Reagent (Thermo Fisher Scientific), quantified, separated by SDS-PAGE, blotted onto nitrocellulose membrane and incubated with antibodies against ER β (sc-8974, Santa Cruz Biotech.) or β -actin (sc-47778) as a control for gel loading and transfer. Our procedure has been described previously [10]. A band at 55 kDa, specific for ER β , is arrowed; * refers to an unspecific band at 75 kDa. **B.** *In vivo* experiments were conducted in accordance with the recommendations of EEC (86/609/CEE) and with the approval of the Animal Experimental Ethics Committee of our institution (UB-CEEA agreement 251/15). Z138-GFP-Luc, REC1-GFP-Luc, JeKo1-mCherry-Luc, and Granta519-GFP cell lines were engineered using lentivirus or retrovirus infections. Male NSG mice, n = 3 per group (age 6-8 weeks), were injected i.v. with 10^7 cells in a final volume of 100 μ l. The same day, mice were separated into three groups receiving: vehicle (0.01% DMSO), DPN or ERB-041 both at the concentration of 1 mg/kg. Drugs and vehicle were injected i.p. 5 days a week. Tumor engraftment was determined weekly by bioluminescence imaging (BLI). For this aim, mice were injected i.p. with 75 mg/kg of D-luciferine and then analyzed on an Aequoria Luxiflux bioluminescent device equipped with an ORCA-ER camera (Hamamatsu). Mice were euthanized at day 31 (Z138-Luc) or day 41 (REC1-GFP-Luc). Endpoint BLI signal is shown for each treatment group. **C.** MCL cells were treated *in vitro* with DPN or ERB-041 (100 nM or 1 μ M for 48 h or 72 h) or vehicle and assayed for migration.

Cells (5×10^5 cells per insert) were suspended in RPMI 1640 medium containing 0.5% bovine serum albumin (BSA). They were seeded in the top chamber of transwell inserts (Millicell® Hanging Cell Culture Inserts 5 μ m PET, Millipore). Filters were transferred to wells containing RPMI 1640 medium with recombinant human stromal cell-derived factor 1 (SDF1, 200 ng/ml, R&D Systems) as chemoattractant. Plates were then incubated for 4 h at 37°C, and the number of cells migrated in the lower chambers was counted by flow cytometry. As an example, the results obtained for the Z138 cell line treated with 0.1 or 1 μ M ERB-041 or DPN for 48 h are shown. The percentage of migrating cells (treated vs. vehicle) for each culture condition is plotted on the graph. **D.** HUVECs were plated onto a layer of Matrigel (BD Bioscience) at a density of 4×10^4 cells/well. Cells were treated with supernatants of ERB-041-treated (100 nM or 1 μ M for 4 h) or vehicle-treated cells as a control. After 24 h, tubular structures were photographed under a microscope (Olympus IX2-SL). The number of formed capillary tubes was counted in 11 independent fields (Fig S5A) of each well from each culture. The experiment has been done twice with triplicate samples. The number of tubes are plotted in the histograms. **E.** The concentration of VEGF was measured with an ELISA assay (Quantikine ELISA Human VEGF, R&D systems) using the supernatants of Granta519 and JeKo-1 cells treated by ERB-041 (1 μ M for 48 h) according to the manufacturer's recommendations. Samples were assayed in triplicate. The concentration of synthesized VEGF in each culture condition was deduced from the standard curve shown in Fig S5B. ns, non significant; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$ with the Student's *t*-test.

Table 1. Flow cytometry analysis of infiltrated organs in engrafted NSG mice

Cell line	Mouse	Spleen	Blood	Bone marrow	Liver	Lung	Kidney	Testis
JeKo1-mCherry-Luc*	J1	5	no	44	no	nd	nd	no
	J2	15	no	59	no	nd	nd	no
	J3	7	7	45	no	nd	nd	no
Z138-Luc**	Z3	22	no	68	no	nd	nd	nd
	Z4	24	no	75	no	nd	nd	nd
	Z5	38	no	82	no	nd	nd	nd
REC1-GFP-Luc***	R4	no	no	4	nd	nd	nd	nd
	R5	no	no	3	no	nd	nd	nd
	R6	no	no	3	nd	nd	nd	nd
Granta519-GFP†	G1	23	1	57	45	7	9	no
	G4	37	2	21	47	3	10	< 1

*, in the JeKo1-mCherry-Luc series, three mice were sacrificed at day 23. **, in the Z138-Luc series, three mice were sacrificed at day 30. ***, in the REC1-GFP-Luc series, three mice were sacrificed at day 33. †, in the Granta-GFP series, three mice died unexpectedly at day 17, two mice were sacrificed at the same day. At the time of euthanasia, indicated organs were collected; single-cell suspensions were prepared, then stained with IOTest® CD20-PE (phycoerythrin, IM1451, FL2) or the corresponding isotype control and analyzed on an Attune acoustic focusing cytometer (Thermo Fisher Scientific). The percentage of positive cells in each organ is indicated in the table. no, no signal; nd, not done.



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Fig 1

Additional informations

Additional methods

Cell culture and cell proliferation measurement

MCL cell lines have been described previously (Moros *et al*, 2014). Cell lines were maintained in culture in RPMI 1640 medium (Lonza) supplemented with 10-20% FCS (PAA Laboratories), 2 mM L-glutamine and antibiotics (Lonza) in a humid atmosphere at 37°C. Cell authentication was done by short tandem repeat (STR) profiling (IdentiCell, Aarhus, Denmark).

Cell proliferation was assessed by an MTS assay (3-(4,5)-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay, here the CellTiter 96® AQueous One Solution 5promega according to the supplier's instructions.

Transwell migration and invasion assays

For migration assay, 5×10^5 cells in serum-free medium plus 0.5% BSA were added to the top chamber of 24-well inserts (Costar Transwell® Permeable Support, pore size 5 μ m). For invasion assay, the same number of cells were seeded in transwell inserts coated with extracellular matrix ECM obtained from Engelbrecht-Holm-Swarm mouse sarcoma (Sigma-Aldrich). Medium supplemented with SDF1 (200 ng/ml) or not (for control), was added in the bottom chambers. Plates were incubated for 4 h (migration) or 24 h (invasion) at 37°C. Migrating and invaded cells present in the lower chambers were counted by flow cytometry. The accuracy of cell count was checked by the use of fluorescent particles added in the chambers (Accucount Fluorescent particles, SpheroTech).

Tube formation assay

HUVECs were plated onto a layer of Matrigel (BD Bioscience) at a density of 4×10^4 cells/well in 24-well plates. Immediately after, cells were treated with supernatants of DPN/ERB-041-treated (100 nM or 1 μ M for 48 h) or vehicle-treated MCL cells. Cultures were observed 24 h later under an inverted microscope (Olympus IX2-SL, X 40 magnification) and the number of formed capillary tubes counted on 11 representative fields. A junction was recorded when a tube was bound to, at least, one another tube.

Western blotting

Proteins were purified from cultured MCL cell lines including GFP/mCherry/Luc-expressing cells with the M-PER™ Mammalian Protein Extraction Reagent (Thermo Fisher Scientific), quantified, separated by SDS-PAGE, blotted onto nitrocellulose paper and incubated with antibodies against ER β (sc-8974, Santa Cruz Biotech.) or β -actin (sc-47778) as a control for gel loading and transfer. Our procedure has been described previously (Moros *et al*, 2014).

MCL cells engraftment in immunocompromised mice

In vivo experiments were conducted in accordance with the recommendations of EEC (86/609/CEE). They were approved by the Animal Experimental Ethics Committee of our institution (UB-CEEA agreement 251/15 in Spain). Z138-GFP-Luc, REC1-GFP-Luc, JeKo1-mCherry-Luc, Granta519-GFP cell lines were engineered using lentiviruses or retroviruses. Male NSG (n = 6 per group) mice (age 6-8 weeks) were injected i.v. with 10^7 cells in a final volume of 100 μ l. Tumor engraftment was determined weekly by bioluminescence imaging (BLI). Mice were injected i.p. with 75 mg/kg of D-luciferine and then analyzed with a Aequoria Luxiflux bioluminescent device quipped with an ORCA-ER camera (Hamamatsu). Photon emissions were captured through the whole mouse body. At the end of the

experiment mice were euthanized. Then, infiltrated organs were collected; single-cell suspensions were prepared, then stained with IOTest® CD45-PE (phycoerythrin, IM1451, FL2) or the corresponding isotype controls as recommended by the supplier.

For ERβ agonists treatment, mice were either engrafted with Z138-Luc or REC1-GFP-Luc. The same day, mice were separated into three groups (n=3 in each one), one receiving DPN (1 mg/kg), another ERB-041 (1mg/kg), and the last one vehicle (0.1% DMSO). Mice were treated five days a week. Mice of the Z138 group were euthanized at day 29, of the REC1 group, at day 39. BLI was recorded as mentioned before.

Additional figure legends

Supplemental Fig S1

Six-week old NOD-*scid* *IL2ry*^{null} (NSG) male mice were injected in the caudal vein with 10⁷ JeKo1-mCherry-Luc, Z138Luc, or REC1-GFP-Luc cells. Mice were weekly analyzed for BLI starting one week after cells injection.

Supplemental Fig S2. Effect of DPN and ERB-041 treatment on MCL tumor cell infiltration in vivo.

NSG mice were injected intravenously with Z138-Luc cells and received a daily dose of DPN (D, 1 mg/kg), ERB-041 (E, 1 mg/kg) or the equivalent volume of vehicle (V), for up to 14 days. Mice were then sacrificed and human CD45+ malignant B cells were recounted on a cytometer from spleen, brain, bone marrow extracts and in peripheral blood samples, as described in the methods section. Shown are the relative mean fluorescence intensity (MFI-R) values between CD45-derived fluorescence and isotypic control, calculated in the different compartments and for each treatment group (statistical significance: * $p < 0.05$).

Supplemental Fig S3

Granta519-GFP, JeKo1-mCherry-Luc, REC1-GFP-Luc and Z138-Luc cells were either treated with the vehicle (0.1% DMSO) or various concentrations (0.1-10⁴ nM) DPN or ERB-041 for 48 h. Cell proliferation was assessed using an MTS assay (CellTiter 96® AQueous One Solution Cell Proliferation Assay, Promega). The experiment was performed twice with triplicate samples with similar results. The means ± SD from one representative experiment are reported on the histograms. *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; ns, not significant with the Student's t -test.

Supplemental Fig S4

A. Left panel. JeKo1 and Z138 cultured cells were seeded into the top chamber of transwell inserts. Inserts were transferred into wells containing medium with SDF1 or without SDF1 (Ctrl) and cells were allowed to migrate for 4 h. Cells present in the bottom well were then counted. Three independent inserts were seeded per experiment; the experiment was performed three times. Mean numbers of migrating cells ± SD were plotted on the graph. *Middle and right panels.* Granta519 and JeKo1 cells were treated *in vitro* with vehicle or ERB-041 (0.1 or 1 μM) for 48 h or 72 h. Then they were seeded and assayed for migration as described before. Three independent inserts were seeded per experiment; the experiment was performed three times. The percentage of migrating cells ± SD was plotted on the graph. **B. Left panel.** JeKo1 cells were seeded in transwell inserts coated with extracellular matrix (ECM) proteins. Inserts were transferred into wells containing medium with SDF1 or without SDF1 (Ctrl). Cells were allowed to invade ECM for 24 h. The number of invaded cells is plotted on the graph. The experiment has been carried out twice with triplicate samples. *Middle and right panels.* JeKo1 and Z138 cells were treated with vehicle, DPN (0.1-1 μM) or ERB-041 (0.1-1 μM) for 48 h and seeded in ECM-coated transwell inserts. Inserts were incubated for 24 h and the number of cells present in the bottom wells

counted. The experiment was repeated three times with triplicate samples. The mean ratios (treated vs. ctrl) $\pm$ SD are plotted on the graph. ns, not significant; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$ in t -tests.

Supplemental Fig S5

A. HUVECs were plated onto a layer of Matrigel (BD Bioscience) at a density of 4×10^4 cells/well in the presence of supernatants from JeKo1 and Granta519 cells previously treated with ERB-041 (0.1 or 1 μ M, 4 h) or with vehicle as a control. After a 24 h-incubation period, cells were photographed under a microscope (Olympus IX2-SL). The number of branch points (circled in red) with at least two branches, corresponding to newly formed capillary tubes was counted on representative fields. The experiment has been done twice with triplicate samples.

B. The quantification of produced VEGF was done using the Quantikine ELISA kit (R&D systems) according to the manufacturer' instructions on a Victor X4 plate-reader (Perkin Elmer). The standard curve was drawn from the OD at 450 nm of calibrated VEGF concentrations ranging from 10^3 to 15.6 pg/ml.

Additional reference

Moros, A., Bustany, S., Cahu, J., Saborit-Villarroya, I., Martinez, A., Colomer, D., Sola, B. & Roué, G. (2014) Antitumoral activity of lenalidomide in *in vitro* and *in vivo* models of mantle cell lymphoma involves the destabilization of cyclin D1/p27KIP1 complexes. *Clinical Cancer Research*, **20**, 393–403.

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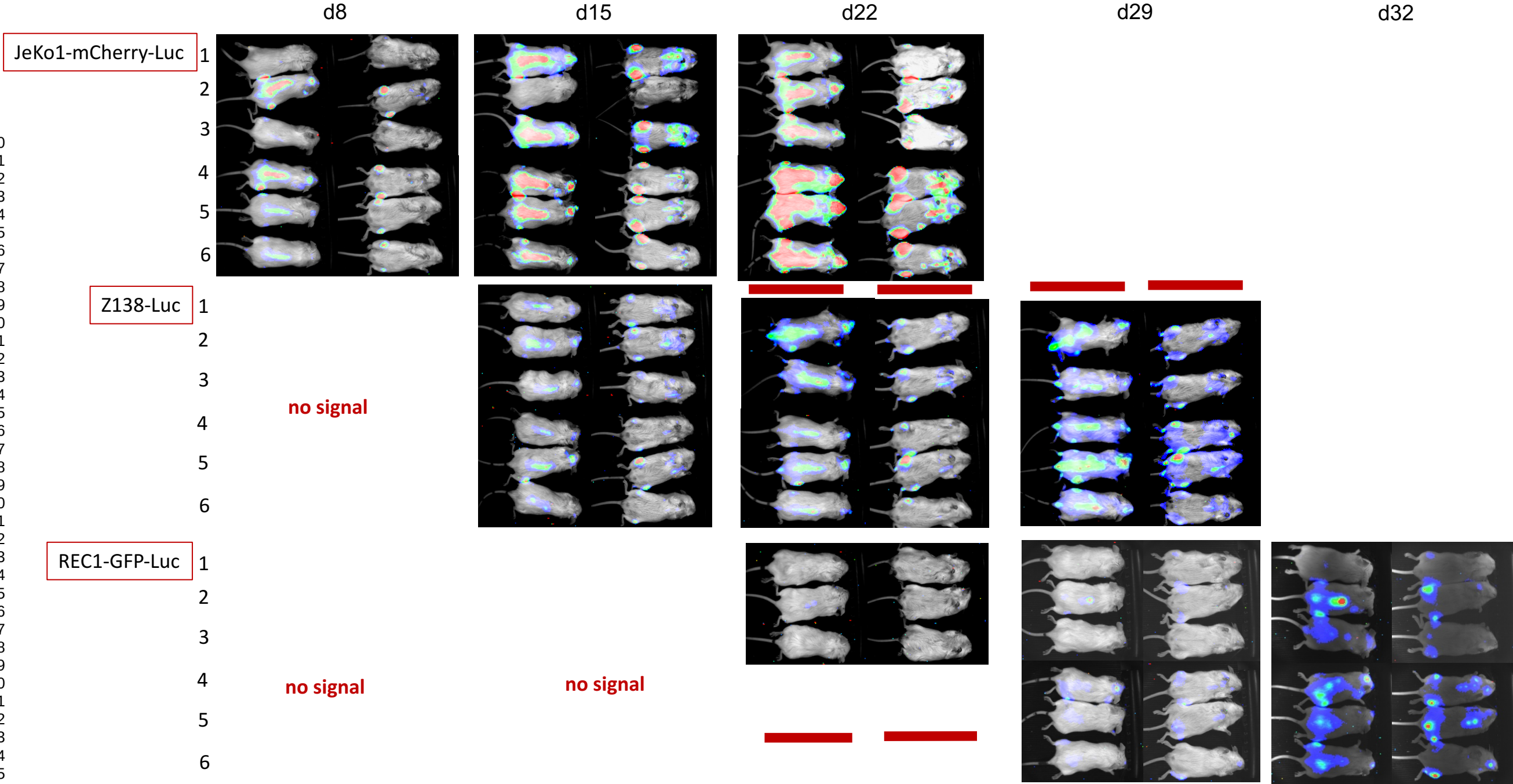


Fig S1

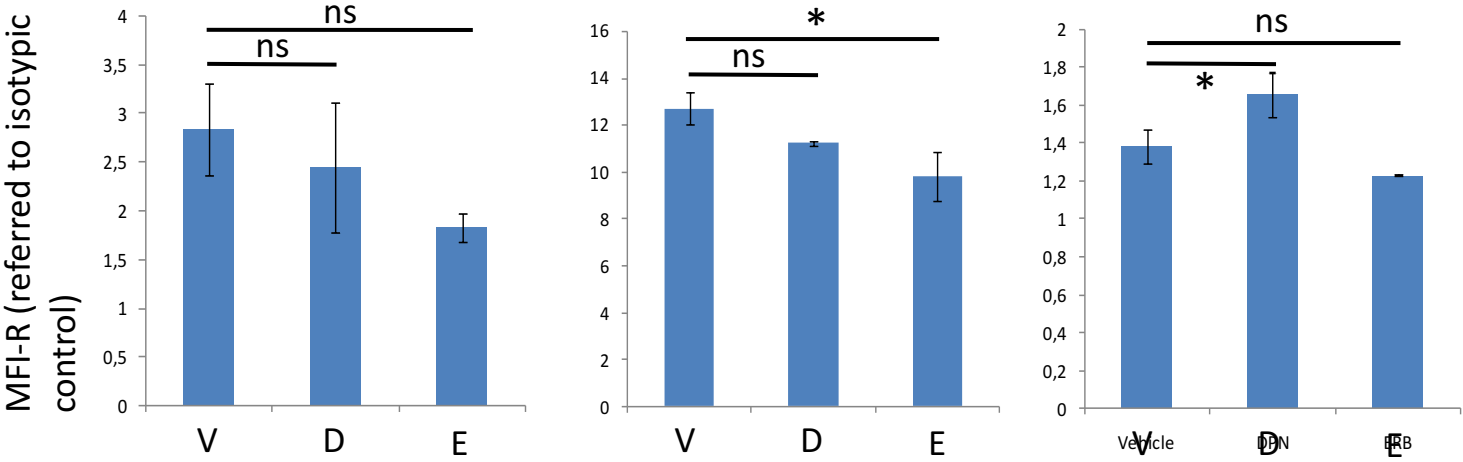


Fig S2

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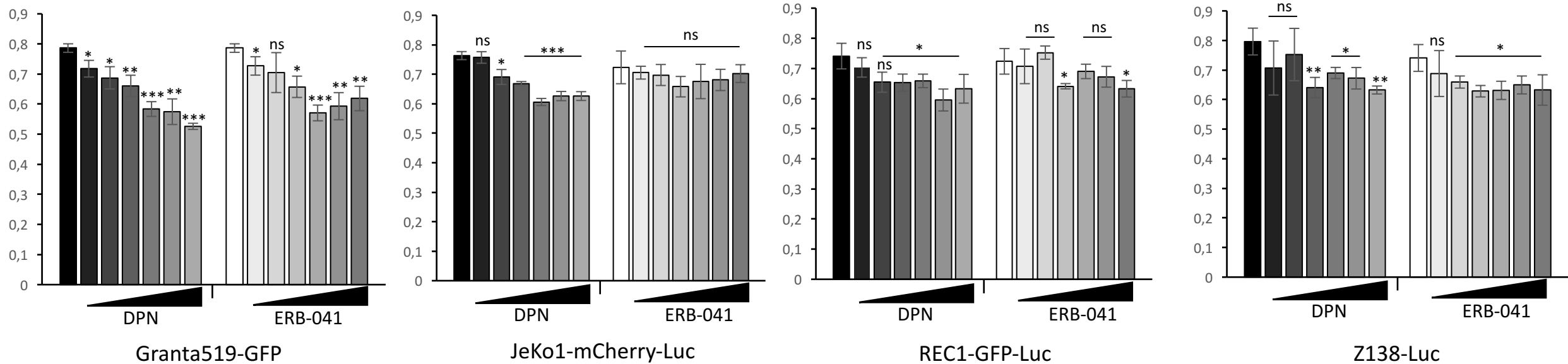
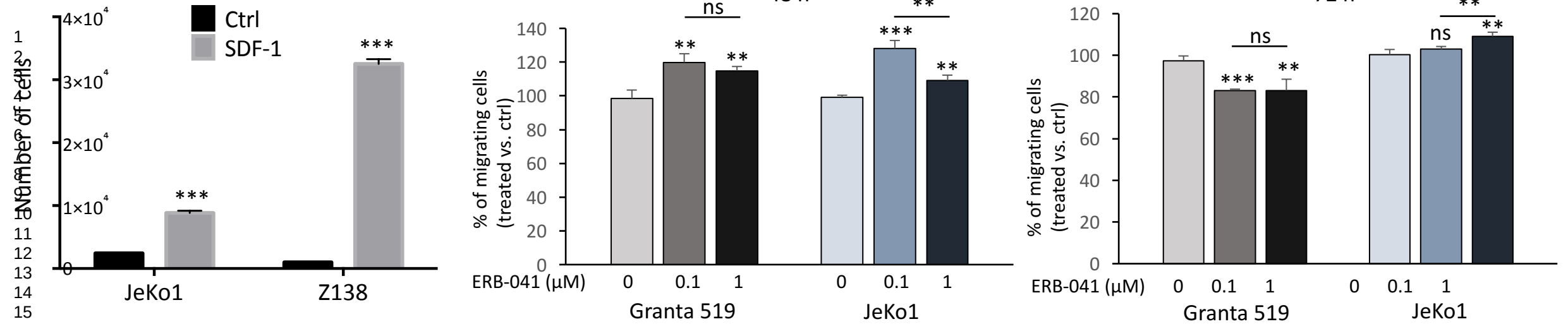


Fig S3

A



B

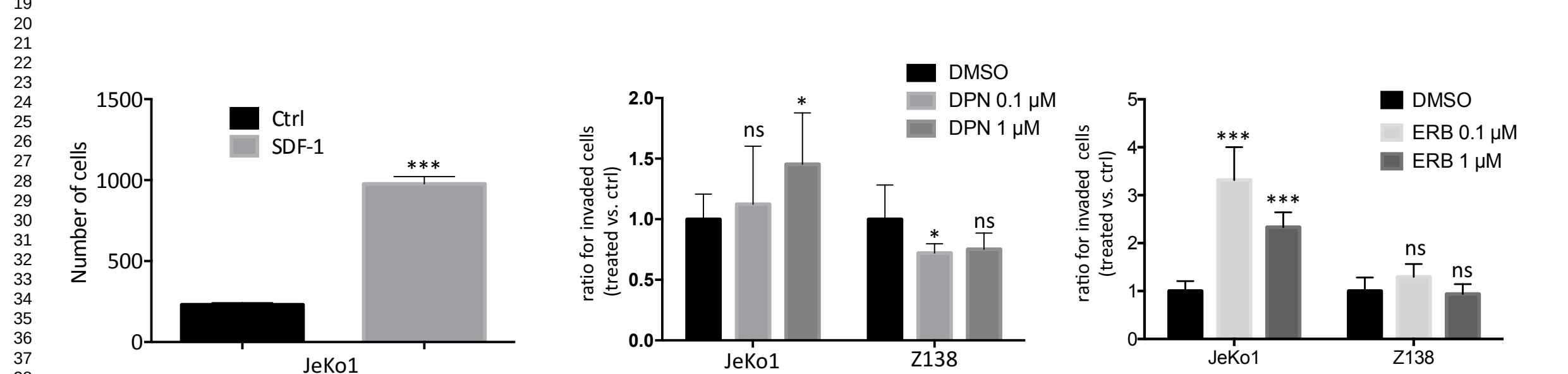
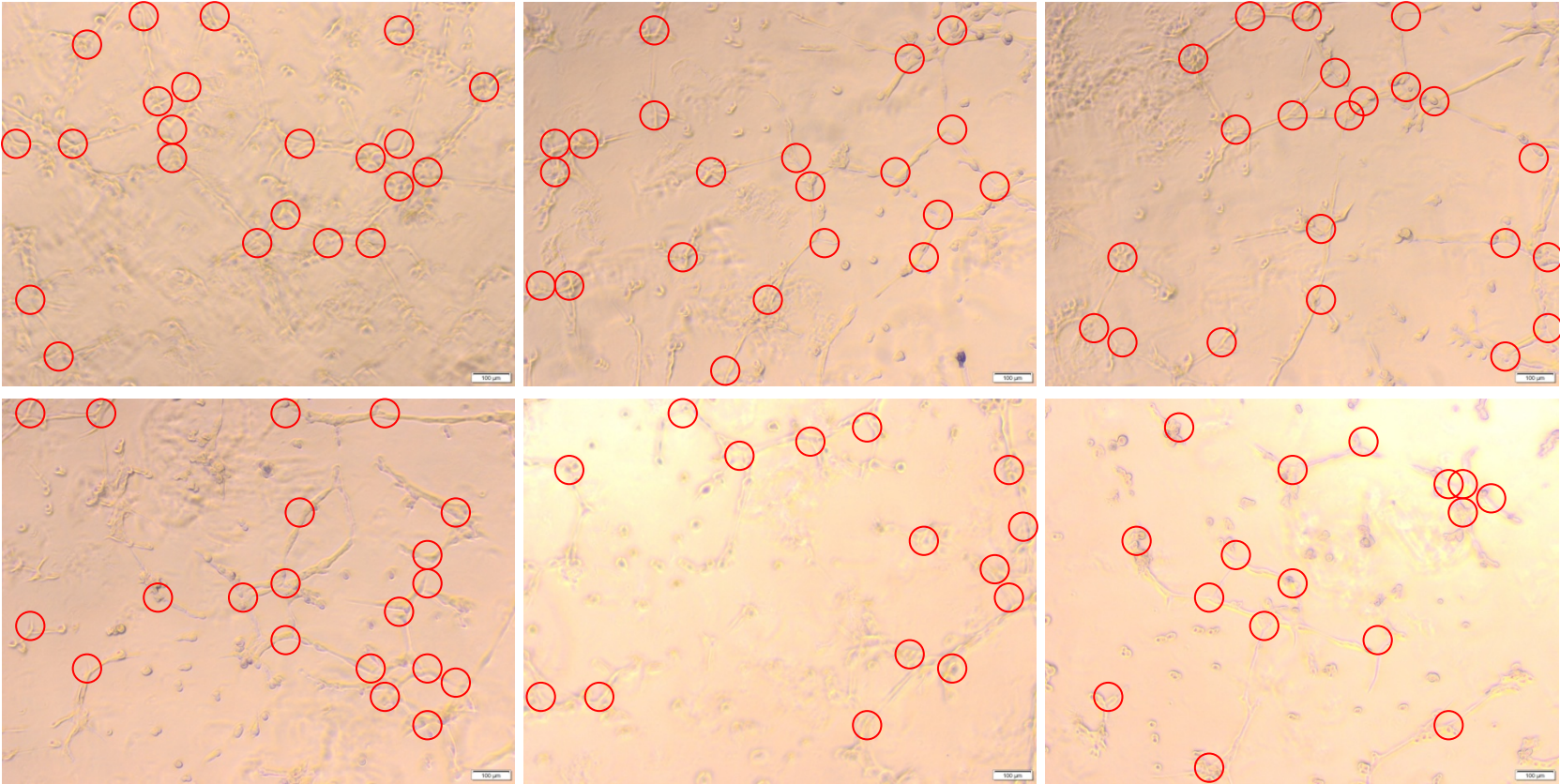


Fig S4

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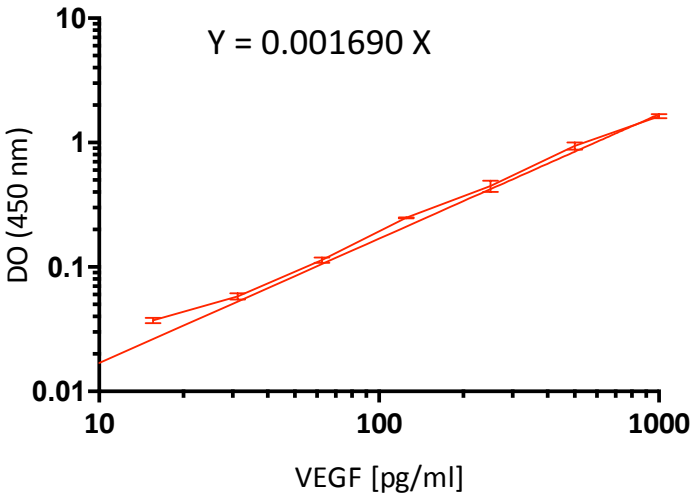


Fig S5